INSTITUTE NOTES.

JUNE, 1941.

NEW MEMBERS.

The following elections have been made by the Council in accordance with the By-Laws, Sect. IV, para. 7.

Elections are subject to confirmation in accordance with the By-Laws, Sect. IV, paras. 9 and 10.

Transferred to Fellow.

HYAMS, Harry . . . . . England.

As Member.

GOODHIND, William Henry ... ... England.

Transferred to Member.

IVES, Herbert Charles ... ... England.
SKILLING, Norman L. ... ... England.

As Associate Members.

GOLDSTEIN, Richard Frank ... ... England.
WARDLAW, Harold Wilberforce ... ... Trinidad.
WILLIAMSON, David Kenneth Caird ... ... Sydney.

Transferred to Associate Member.

JENNINGS, W. Munro, Jr. ... ... England.
STREETON, Reginald Douglas ... ... England.

As Students.

HIRST, Norman ... ... England.
HUGHES, Fred ... ... England.
TURNER, Eric Braybrooke ... ... England.

CANDIDATES FOR ADMISSION.

The following have applied for admission to the Institute or transfer to another grade of membership, and in accordance with the By-laws the proposals will not be considered until the lapse of at least one month subsequent to the issue of this *Journal*, during which any Fellow, Member, or Associate Member may communicate by letter to the Secretary, for the confidential information of the Council, any particulars he may possess respecting the qualifications or suitability of any candidate.

The object of this information is to assist the Council in grading candidates according to the class of membership.

The names of the candidate's proposer and seconder are given in parentheses.

KRONSTEIN, Joseph Alexander, Economist, Ragosine Oil Company. (*G. J. Vineall; C. W. Wood.*)

LEITCH, James Morton, Engineer, H.M. Forces. (*C. M. Leitch.*)

ARTHUR W. EASTLAKE,
Honorary Secretary.

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Vol. 27. No. 212. June 1941.

PETROLEUM AS A RAW MATERIAL.*

By Professor A. W. Nash, M.Sc., M.I.Mech.E., M.I.Chem.E.

Introduction.

It is common knowledge that petroleum contains innumerable compounds, both organic and inorganic; these varying in extent from traces of radioactive and other rare elements to the more preponderant paraffins, olefines, and cyclic compounds. Further, containing as it does the prolific elements carbon, hydrogen, oxygen, sulphur, and nitrogen, it is clear that the number of compounds and mixtures which are potentially possible to separate by physical and chemical methods and technique is beyond computation. Thus, limitations to the subject-matter to be covered by an address of this nature and duration have to be strictly confined to a small fraction of the possibilities.

It is proposed to treat the subject only in so far as pure chemical entities can be isolated or obtained from or through the intermediary of petroleum. Gasolines, kerosines, lubricants, oils of all grades and qualities are thus excluded. Again, in this view, only the peaks of the vast panorama can be singled out for a passing second, leaving the other interesting landmarks for more detailed study.

Perhaps it is not out of place to state that when dealing with the occurrence, isolation, or production of certain substances from petroleum, these substances may not actually occur as such in crude petroleum. To illustrate the point, it is probably true to say that olefines do not occur in undistilled crude; yet these reactive compounds are abundant in distillates of even narrow boiling ranges.

Under such limitations it appears convenient to adopt an arbitrary scheme, and consider the properties and applications of compounds under six separate headings: saturated, unsaturated, and oxygenated open-chain groups of hydrocarbons, cyclic compounds, sulphur compounds, and nitrogen compounds.

The Paraffins.

The normal paraffins occur in crude oil and its distillates, and all members up to C_{36} have been studied and their properties reported in the literature. Higher members very probably occur, but these have been isolated chiefly from the products of Kogasin synthesis, not from petroleum.

The importance of liquid propane and butane is increasing rapidly, particularly for domestic and industrial fuels. Propane has the advantage of low boiling point, high octane number, refrigeration qualities, and

* Address delivered by the President at a Meeting of the Institute in London, on 1st May, 1941.

special value as a metal-cutting fuel. The two fuels have certain advantages over gasoline in internal-combustion engines, but they are still in no position to replace it. Mixtures of propane and hydrogen or butane and hydrogen to yield fuels of the density of air and of definitely controlled qualities are proposed for use in airships.

The use of pure branched paraffins as high-octane fuels is so well known that it needs only a passing mention. *iso*-Octane is, of course, the standard reference fuel.

Thermal Decomposition.

The exact mechanism of thermal decomposition of the normal paraffins is not understood in all cases—thus primary dissociation of methane to methylene radicles and hydrogen is proposed by one school, and to a methyl radicle and hydrogen by another, and even here the exact electronic constitution of the methyl or methylene radicle is not known. Still, by either mechanism thermal decomposition of methane yields hydrogen. In the presence of mercury or cadmium vapours methane may be converted into higher hydrocarbons by heat treatment between 400° and 1100° C. Ethylenic and acetylinic compounds are produced by the application of the glow-discharge method. Acetylene may be produced catalytically from methane alone, or methane and oxygen, or air under strict control.

When the higher members of the paraffins are subjected to pyrolysis under catalytic influences, higher members of olefines as well as ethylene are produced, together with aromatic and naphthenic hydrocarbons. The importance of these dehydrogenation processes lies in the fact that the olefines themselves may serve as the raw material for further chemical reactions. Thus an inert paraffinic hydrocarbon is converted into a most reactive compound. Similarly, catalytic cyclization of aliphatic hydrocarbons may be used as such (solvents, fuels, etc.), or as the raw material for nitration, sulphonation, in dyestuff and similar manufacture.

Reaction with Steam.

The reactions of the paraffin molecule with others are limited, but certain of these are important industrially. Thus one of the more important industrial methods of producing hydrogen is the partial oxidation of methane or the reaction of this gas with steam. It is to be noted that although the general result of interaction of steam and methane homologues is hydrogen and carbon monoxide or dioxide, in certain cases alcohols are produced. A 57 per cent. yield of methyl alcohol is, for instance, obtainable from methane and steam. Substituting steam by carbon dioxide still yields hydrogen in appreciable quantities.

Again, subjecting methane and ammonia in the presence of oxygen to high temperatures results in the production of hydrocyanic acid and nitrogen as by-product.

$$2CH_4 + 2NH_3 \longrightarrow 2HCN + 6H_2 \xrightarrow{3O_2} 6H_2O$$

Reaction with Halogens.

By strictly controlling the reaction, methane may be chlorinated thermally, catalytically, or photochemically. Chloromethane may be the predominating product under selected conditions. Hydrolysis of monochloromethane produces methyl alcohol, whilst the interaction with carbon monoxide results in acetylchloride.

$$CH_3Cl \xrightarrow{NaOH} \underset{\text{methyl alcohol.}}{CH_3OH} + NaCl$$

$$CH_3Cl + CO \longrightarrow \underset{\text{acetyl chloride.}}{CH_3{\cdot}CO{\cdot}Cl}$$

Progressive halogenation yields dichloromethane, chloroform, and carbon tetrachloride. Formaldehyde and chloroacetaldehyde may be produced from the dichloromethane:

$$CH_2Cl_2 \xrightarrow{2NaOH} CH_2\begin{matrix}OH\\OH\end{matrix} + 2NaCl$$

$$CH_2\begin{matrix}OH\\OH\end{matrix} \xrightarrow{-H_2O} HCHO \xrightarrow{CH_2Cl_2} CH_2Cl{\cdot}CHO + HCl$$

Further, $CH_2Cl_2 + CO \longrightarrow ClCH_2{\cdot}COCl$—*i.e.*, monochloroacetyl chloride, which is a potential source for monochloroacetic acid, is produced from the reaction with carbon monoxide. Thus methane, an inert saturated molecule, is transformed progressively to aldehydes and chlorobodies of great potentialities.

Chloroform is well known for its anæsthetical, solvent, and extraction properties. Carbon tetrachloride is characterized by the versatility of its uses, as can be seen readily from the following list:

Dewaxing or refining agent for lubricating oils;
Decarbonizing agent for I.C. engines and cleaning agent for metals;
Preparation of sand moulds;
Preparation of cosmetics;
Mixed with wax-like ketones, as polishing composition;
Preparation of die lubricants;
Production of chloral by interaction with formaldehyde;
Preparation of insecticidal sprays;
Preparations of dry-cleaning agents;
Preparations of fire extinguishers.

Further, it is used to produce chlorofluoromethanes, by interaction with antimony trifluoride, which mixed halides are useful as refrigerants because of their low boiling points, non-flammability, and low toxicity, or as solvents for cleaning operations.

Similarly, chlorinated paraffins of higher molecular weight are produced and used as solvents, refrigerants, in dry-cleaning, in insecticides, and in lacquers. As the number of isomers becomes greater with the higher mono- and dichloro-paraffins, so does the difficulty of controlling the reaction to yield a predominating amount of any one desired product.

A detailed discussion of the reactions of alkyl halides to yield olefines, acids, or condensation products with other hydrocarbons is beyond the scope of an address of this nature. Fortunately many of these reactions are well known in general organic chemistry. Reference to them is made here only to stress the importance of petroleum as a raw material.

Oxidation of Paraffins.

Further, by oxidation of the paraffins found in petroleum and its distillates large numbers of oxygen-containing derivatives have been produced or detected. Alcohols, aldehydes, ketones, and acids, together with aldehyde-acids, aldehyde-alcohols, keto-acids, and aldehyde-hydroxy-acids, have been found, as well as the esters of these acids. To produce such compounds involves many interesting and important pyrolytic-oxidation reactions.

Sufficient, however, has been said to sketch the vast number of substances it is possible to produce from the paraffins alone.

Unsaturated Hydrocarbons.

Olefinic, diolefinic, and acetylenic compounds occur in distillation and cracking products. Of the former up to $C_{18}H_{36}$ (octadecene) have been identified in certain kerosine fractions. Certain branched-chain olefines have also been studied.

The importance of the mono-olefines lies in their reactivity; thus they form chemical intermediates. Cracking of the lower paraffins is of special significance in this respect, for they are available in very large quantities, and constitute the most promising of raw materials. Acetylene and butadiene can be produced by cracking of the same raw materials under controlled conditions.

It is of interest to note that ethylene and propylene have a direct use as anæsthetics. The use of ethylene produces a deep surgical anæsthesia rapidly with very early analgesia. There appears to be no apprehension of asphyxia and very few symptoms of danger such as nausea and cyanosis. Danger of asphyxia is still smaller, if the gas is diluted with oxygen. The purity of gas has to be, of course, of a very high order.

Pyrolysis and Polymerization.

Pyrolysis of mono-olefines under controlled conditions results (1) in isomerization; (2) in dissociation into hydrocarbons of lower molecular weight and hydrogen; and (3) in polymerization to yield hydrocarbons of higher molecular weight.

$$CH_3{-}CH{=}CH_2 \longrightarrow CH_3{-}C{\equiv}CH + H_2$$

$$CH_3{\cdot}CH{=}CH_2 + CH_3{\cdot}CH{=}CH_2 \longrightarrow CH_2{=}CH_2 + CH_3{-}CH{=}CH{\cdot}CH_3$$

$$CH_2{\cdot}CH{=}CH_2 \longrightarrow CH_4 + CH{\equiv}CH$$

$$CH_2{\cdot}CH{=}CH_2 + CH_3{-}CH{=}CH_2 \longrightarrow CH_4 + CH_3{-}CH{=}CH{-}CH{=}CH_2$$

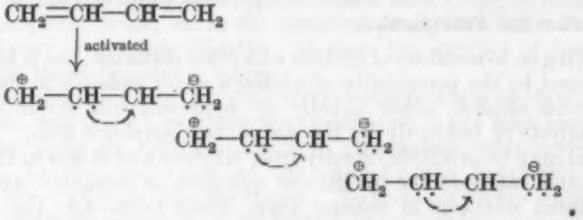
1 Methyl butadiene

$$CH_2{\cdot}CH{=}CH_2 + CH_3{\cdot}CH{=}CH_2 \longrightarrow C_6H_{12}$$

and so on.

Thus, even a simple molecule like propylene yields most complex results because of secondary reactions. A full study of the complete range of reactions involved is well-nigh impossible. This fact, however, need not be discouraging, for studies on simple lines have yielded valuable results. Pyrolysis of acetylene yields aromatics under suitable conditions.

Probably of greatest interest in this connection is the polymerization of olefines and diolefines. Polymer gasoline, synthetic lubricating oils, and rubber form such products of immense value. The butadiene used in synthetic-rubber manufacture is obtained either from ethyl alcohol or from petroleum cracking; but it is purer when obtained from alcohol. The diolefine is converted catalytically into a rubber-like composition, which, although it is harder to vulcanize, shows better vulcanization characteristics with sulphur than does natural rubber.



Growth ceases when a molecule of butadiene polarizes into

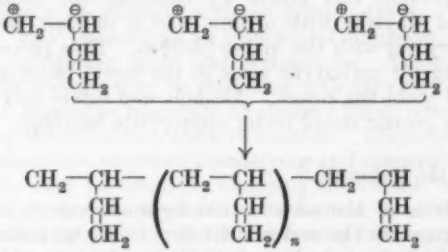
$$\ominus CH{=}CH{-}CH{=}CH_2 + \oplus H$$

and the two ions attach themselves to the ends of the chain giving

$$CH_2{=}CH{-}CH{=}CH{-}(CH_2{-}CH{=}CH{\cdot}CH_2)_x{-}CH_2{-}CH{=}CH{-}CH_3$$

which is the 1–4 addition.

The reaction may go on in another form, the 1–2 addition.



The reaction stopping either by an ionized molecule of butadiene or by a negative end of a polymer chain coming into juxtaposition with a positive end, and thus neutralizing each other. Various other complexes are possible, as, for instance, the branches of the 1–2 chain going into 1–4 chains themselves.

The synthetic material is already in use in tyres, rubber soles, and heels, ebonite goods, raincoat cloth, gasoline hose, and tyre tubes.

Higher polymers of *iso*butene appear to have potential use in safety glass, plywood, adhesive plaster, flypaper, greases, lubricating and insulating oils, chewing-gum, wax for sealing tree-wounds, decay preventative and cleansing compounds. Polymers of diolefines have particular value as dopes to increase viscosities and viscosity indices of oils, rubber substitutes, vulcanizable products, and coating and insulating materials.

This absorbing subject must be closed by mentioning the relatively recent new types of synthetic rubber made from the co-polymerizing of olefines with small amounts of diolefines to yield complexes less unsaturated than natural rubber, and thus superior in certain properties, such as stability, durability, freedom from impurities, taste, odour and colour, resistance to tear, abrasion and to mineral acids, and of remarkable electrical properties. This " butyl rubber " is a 100 per cent. petroleum product.

Hydration and Esterification.

Moving on to reactions of olefines with other materials, one is immediately impressed by the potentiality of adding a water molecule to the olefine to synthesize alcohols either directly by hydrating with steam in presence of catalysts or indirectly by the use of, say, sulphuric acid. Thus ethyl alcohol may be produced directly from ethylene and steam in the presence of organic catalysts like pyridine or quinoline, or inorganic catalysts such as diluted solutions of mineral acids, acidic salts—*e.g.*, the acid phosphates—or oxide catalysts, as alumina or clays. Similarly *iso*propanol is produced from propene and steam in presence of such catalysts. Phosphoric acid on pumice is a catalyst for normal butenes and milder catalysts such as dilute nitric acid for the *iso*butenes. The case of the higher alcohols from hydration of higher members of the olefines is not so well known.

The interaction of mineral acids, such as sulphuric acid and olefines, to give direct esterification is of interest both from the point of view of producing the alkyl esters and of using these as intermediates in the synthesis of alcohols and ethers by choosing the conditions. Direct esterification of ethylene with organic acid is difficult, but this reaction is easier to carry out with the higher olefines. Thus propene reacts fairly readily with organic carboxylic acids in the liquid phase and in presence of catalysts to yield the esters. Alcohols and esters and their uses will be discussed in greater detail under appropriate headings.

Reactions with the Halogens.

A characteristic of the unsaturated hydrocarbons is that they react with the halogens readily and additively; in contradistinction with the paraffins, which do so only by substitution. In fact, this characteristic is the basis for many methods of estimating the olefinic content of a substance by bromine and iodine numbers.

Ethylene dichloride, product of interaction of ethylene and chlorine, can be converted into chloroacetic acid in the presence of oxygen and ultra-violet light of short wave-length. It may be converted into ethylene glycol by hydrolysis with aqueous sodium carbonate, or to the glycol diacetate by heating with anhydrous salt of acetic acid. Interaction

with ammonia yields, under certain conditions, ethylenediamine. All these compounds have their specific uses—the last, for instance, as a softening medium for the hydrolysis of cellulose acetate yarn or for increasing knock rating of motor fuels by the addition of 0·5 per cent. Further, they are intermediary compounds in the chemical industries.

Plastics may be produced from ethylene dichloride and alkaline-earth sulphides. As a solvent the dichloride has very desirable properties—high solvent power, low inflammability, and availability in large quantities. Many other uses of this compound are suggested and are being made, but it is sufficient to reflect that this compound is only one of many, such as the dibromides or di-iodides of ethylene, as well as the various dihalides of higher homologues of ethylene. Thus, to take an example at random, propene dichloride may be used as an insecticide; as a paint remover; or, since it forms azeotropic mixtures with water, to dehydrate acetic or propionic acids; or in the chemical preparation of a dinitrile, propene glycol, or propene diamine. In fact, the number of reactions possible with these dihalides is legion.

Again, the reaction of, say, ethylene and chlorine in water yields ethylene chlorohydrin, which is an excellent insecticide, and it has been suggested as a refining agent for rosin or to remove naphthalene compounds from petroleum. In chemical synthesis the chlorohydrins obtainable from petroleum have many an important place. To show only a few important instances, synthetic resins may be formed from ethylene chlorohydrin condensed with urea or methylurea. On the other hand, ethylchlorohydrin treated simultaneously with chlorine and an excess of ethylene yields β, β′-dichlorodiethyl ether—the basis of the "chlorex process."

Olefine Oxides.

Another class of products obtainable from the olefines is that of olefine oxides to be produced from the olefine halohydrins and alkalis or from the direct oxidation of the olefines. A typical member may serve. The principal application of ethylene oxide is that of a chemical intermediary in the manufacture of solvents such as glycol ethers. The compound itself, however, may be used as an insecticidal fumigant, particularly in such cases as fumigating ships and warehouses. Aliphatic nitrates in conjunction with acetone may be stabilized with ethylene oxide for treating leguminous vegetable materials to destroy their bitter components, and for reducing the nicotine content of tobacco. Ethylene oxide reacting with marine-animal oils produces emulsifying and dispersing agents.

A further step may be taken by changing the olefinic oxide (obtained from the chlorohydrin, which was in turn formed from the olefine) into olefinic alkylamines by treating it with ammonia. These compounds are of many uses, one of which, for instance, is that of making soaps to be used in dry-cleaning, or in cosmetics in conjunction with glycols, in products for glazing or finishing textile material, in separating wax from oils, or in oil-proofing porous fibrous materials.

The reactions of the olefines and the possibilities arising therefrom are far too numerous even to be listed in this short address. Additive reactions alone include, aside from those already discussed with the halogens, those with aromatic, paraffinic and naphthenic hydrocarbons, with phenols

and acids, with acid halides and ammonia and amines, aside from other types of reactions with inorganic compounds such as oxides and halides of sulphur and nitrogen, and such important reactions as the condensation of the unsaturated hydrocarbon with aldehydes to yield synthetic resins.

It is to be noted that only one member of one type of the unsaturateds has been so lightly sketched—*i.e.*, the first of the mono-olefines—and with the exception of butadiene it has not been possible to mention anything regarding the other families of unsaturated hydrocarbons found in petroleum products or produced from them. The field is truly vast, and the greater the contemplation the farther back the horizon appears to recede.

Oxygen-Containing Groups.

The Alcohols.

The direct and indirect hydrations of olefines into alcohols have already been mentioned. Perhaps the most important of the monohydric alcohols is ethanol. This alcohol is produced from ethylene and steam, catalytically, or ethylene and sulphuric acid, giving an ester which, on hydrolysis, yields the alcohol. Ethyl chloride reacts with the alkaline hydroxides, oxides, and steam to yield ethyl alcohol too. Incidentally, the reactions of the alkyl halides may be made to yield primary, secondary, or tertiary alcohols from methanol upwards, in contradistinction from the hydration processes of olefines, which yield secondary and tertiary alcohols only, with the exception of ethanol and, of course, complete absence of methanol.

Ethyl alcohol is finding increasing use as motor fuel, solvent, and intermediary compound in chemical industries to produce a wide variety of organic compounds such as diethyl ether, ethyl esters, acetaldehyde, crotonaldehyde, normal butanol, acetic acid, or acetic anhydride, as well as a large number of ethylated bases such as ethyl aniline. These names alone suggest vast potential and actual values for petroleum as a raw material.

Overhead gas from stabilizer operations yields a propane–propene mixture, the latter component of which yields *iso*propyl alcohol on contact with sulphuric acid. The main industrial applications of this alcohol are connected with its solvent properties. It is used extensively in preparing perfumes and cosmetics, including shampoo, odorants, plant extracts, and medicinal products for external use. An important application is further found in preparing anti-freeze mixtures for car radiators, because on dilution with water a mixture of this alcohol and methanol does not attack metal parts, rubber, or varnishes. It is now possible to obtain, commercially, various derivatives of *iso*propyl alcohol. Acetone and *iso*propyl ether are the two most important of such products. The ether is not only a very valuable solvent, but is a blending compound for high-octane fuels—the blending is, in fact, reported to be better than that of technical *iso*-octane.

Aside from the unique case of *iso*propyl-ethylene, which gives only polymerization products with strong sulphuric acid, higher members of the olefines, such as the *n*-butene and *n*-pentene, yield secondary alcohols, or tertiary alcohols—for instance, trimethylethylene giving *tert.*-pentyl

alcohol. The last group polymerize on contact with strong sulphuric acid.

Generally, the secondary alcohols find uses in the production of ethers, ketones, acids, and esters. For instance, the acetate ester of secondary butyl alcohol is finding widespread use as a lacquer solvent and thinner.

Tertiary alcohols, again, produce ethers and esters. The alcohols themselves may be used in solvent-refining processes to free oils from wax and asphalts, or mixed with propene chloride as a solvent for cellulose acetate.

Glycols and Glycerine.

Another important class of this nature is that of the glycols produced from products of petroleum. These glycols may be either those derived by the hydroxylation of olefines, where the hydroxyl groups are attached to adjacent carbon atoms, or those in which the hydroxyl groups are more remote from each other, as in trimethylene glycol. Both types may be produced from petroleum products.

The very large quantities of ethylene available in gases from cracking operations made this gas an attractive raw material for the synthesis of ethylene glycol. The methods used for glycol production may be either direct mild oxidation of the unsaturated hydrocarbon at its double bond or hydrolysis of derivatives of alcohols. Although the first operation may be used by utilizing potassium permanganate, or persulphuric acid, or even potassium chlorate, the oxidation being catalysed by osmium tetroxide, the hydrolysis method is more often employed.

Taking ethylene glycol as a typical (and the most commonly used) member, this dihydric alcohol may be prepared from the dihaloethanes, ethylene halohydrins, or from glycol esters. Ethylene dibromide and dichloride have been hydrolysed using alkaline carbonates to give ethylene glycol. This glycol has been used in many capacities, chief amongst which are the uses as anti-freezing complex, as a preservative, and in cosmetics. It is a good solvent for many organic substances, and is used in extracting vegetable matter from red rose petals, Brazil wood, carmine, buttercups, etc. It has also been proposed as a solvent for insecticidal compositions such as pyrethrins, and for gum-forming constituents in gasolines. The use of this glycol alone or with 10 per cent. ethanol has been suggested to prevent ice formation on propellers of airplanes. To illustrate its versatility it has been used to reduce the viscosity of nitrocellulose; employed in hydraulic brake fluids; added to solid carbon dioxide to reduce the size of the crystals and thereby improve its mechanical properties, and even as an electrolyte for batteries of certain characteristics, making them valuable for maintaining a grid-bias on a vacuum tube.

Glycol esters and ethers are of importance too, the first as plasticizers, particularly the lower members, and the latter as solvents and diluents; but a study of the derivatives of glycols is a major branch of chemistry in itself.

The synthesis of glycerine on a commercial scale has been the aim of many eminent scientists. Recently an increasing number of patents have been appearing in the literature pertaining to the synthesis of this important compound. Of the numerous methods possible, however, the

most direct are those starting with the 3-carbon skeleton. This is particularly interesting to the petroleum industry, as unlimited quantities of propylene and propane are available from this source. Of the great number of possible syntheses, one line was recently chosen as promising the greatest degree of commercial success. The line of reactions starts with propylene and proceeds to allyl chloride. Allyl chloride is converted either to allyl alcohol or glycerine dichlorohydrin, either of which products is converted to glycerine. "Hot chlorination" of propylene is the key discovery in this process, *i.e.*,

$$2(CH_2 = CH{-}CH_3) \xrightarrow[+\,Cl_2]{500^\circ\,C.} 2(CH_2 = CH{-}CH_2Cl).$$

The yield of allyl chloride is about 85 per cent.

The Aldehydes.

The study of the aldehydes obtainable from petroleum as a raw material may be illustrated by the first and the most important member of the series, formaldehyde. This compound is an oxidation product of methyl alcohol, and this process of obtaining the aldehyde is still the most common one, since it is simple, reasonably cheap, and the product is readily purified. Oxidation of the higher members of the primary alcohol family results in corresponding members of the aldehyde series. Dehydrogenation of the primary alcohols similarly results in the aldehydes, but the usual procedure is catalytic oxidation by air or oxygen. With the higher members there is a tendency towards degradation into lower members.

As large quantities of hydrocarbons are available in natural gases, and these at very low costs, direct catalytic oxidation of the hydrocarbons into the aldehydes has attracted attention, and this process is used industrially. Electro-catalytic processes are also proposed, utilizing the highly reactive oxygen produced from the decomposition of nitrogen oxides in the immediate region of an electric arc to oxidize methane or other hydrocarbons into the aldehyde.

The extremely high reactivity of the carbonyl group of the aldehydes places this class of compounds amongst the most important substances for purposes of synthesis. Thus, the reactions of this homologous series are multitudinous and of greatly varying types. Various higher oxidation products such as the carboxylic acids are obtainable from the aldehydes. Reactions of formaldehyde with the alcohols result in condensation products, certain of which are used to produce readily emulsified materials useful in treating textiles. The lower aldehydes can be made to yield higher members by using alcohol condensation as an intermediary step. However, probably one of the most important reactions of formaldehyde for industry is that of its condensation with such substances as phenols, urea, or casein to yield synthetic plastics. Other industrial utilizations of formaldehyde are there, such as its use to precipitate proteins in making water-proof glues, coating material or cements, etc.; but even in the absence of any other use, this property of forming plastics would rank formaldehyde amongst the more important compounds of the day. The plastic industry is, incidentally, the greatest consumer of this compound.

Ketones.

Although the ketones may be produced from unsaturated or saturated hydrocarbons, the more general method is still the oxidation of secondary alcohols in a similar manner to the production of aldehydes from the primary alcohols. The reaction is reversible and endothermic, and high temperatures therefore favour the production of the ketones. In the presence of air or oxygen, the reaction may, on the other hand, be made under exothermal conditions. Suggestions have been made to combine the types of reactions, and thus control the temperature.

Primary alcohols, aldehydes, ethers, and esters have been converted into ketones catalytically too; all obtainable from petroleum.

The two most typical of the ketones in the abundance and variation of utility are acetone and methyl ethyl ketone. To illustrate the value of this family of organic compounds obtainable from petroleum as a raw material, only acetone will be considered.

Acetone is one of the best known solvents for water, alcohol, ether and many esters, mineral and vegetable oils. It is used in the preparation of smokeless powder, for storing acetylene, as a fuel, and as a selective solvent for dewaxing oils. In dewaxing processes it may be used either alone or mixed with benzol, tetrahydronaphthalene, water-insoluble aliphatic alcohols, higher ketones, *ortho*-dichlorobenzene, monochlorobenzene, ethylene dichloride, *iso*propyl ether, or kerosine. This list illustrates its wide range of solvent power. Acetone has been recommended as a constituent of paint and varnish removers, and this process is widely used in decolorizing women's finger-nails in the eternal search after so-called beauty.

It is incorporated in a special lubricant recommended for chassis, which lubricant, when kept under pressure without air, is of high fluidity, but which assumes a heavy consistency when exposed to the atmosphere.

Again, acetone has been used in cleansing agents, as a solvent for wood preservers, as a pickling solution for steel when mixed with sulphuric acid, and in the preparation of gun-cotton and dopes for aircraft fabrics.

The chemical reactions of acetone, and the derivation of various compounds therefrom, are of great interest. The preparation of cyanohydrins, and amines, of alcohols, carboxylic acids, and halogen derivatives are general reactions for ketones. The production of such products as ketene and diketene are more specific to acetone, but are of equal importance. In the world of medicine, dihydroxyacetone is reported to be a good antidote for hydrocyanic acid poisoning.

Acids and Esters.

Carboxylic acids may be produced from petroleum hydrocarbons directly by either liquid or vapour-phase oxidation processes, using such agents as air or oxygen, nitrogen peroxide or ozone. High molecular-weight acids thus produced are incorporated in petroleum distillates to yield oils possessing marked penetrating qualities. The alkali salts of these monocarboxylic acids have been suggested for use as liquid dispersions for insecticidal purposes and fungicidal plant sprays. The water-insoluble, petroleum-soluble saturated monocarboxylic acids containing up to 12

carbon atoms, and prepared from petroleum hydrocarbons directly, are reported to act as activating materials for rubber vulcanization. Plastic compounds are produced from condensing these acids with formaldehyde or furfural. Similarly, polycarboxylic acids are condensed with polyhydric alcohols to produce synthetic resins.

Carboxylic acids are, of course, obtainable from the oxidation of the alcohols, glycols, aldehydes, and ketones. These acids may be esterified to yield the required esters. A simpler process, however, is to produce the esters by direct esterification of the olefines so abundant in petroleum products. Sulphuric esters, obtained by the absorption of the olefines in sulphuric acid, constitute important intermediary compounds widely used in commercial production of the corresponding alcohols. Again, alkyl esters may be obtained by a single-stage treatment of the appropriate olefin with the organic acid. Thus *sec.*-butyl acetate may be prepared in this way instead of the esterification of the alcohol.

A far greater number of oxygen-containing organic straight-chain compounds has been neglected than studied in this brief outline of the possible and actual value of petroleum crude as a raw material for this group of compounds. Yet the list is impressive even in its diminutive and curtailed form.

Cyclic Compounds.

Aromatics.

Aromatic hydrocarbons occur in straight-run petroleum distillates to small and varying extents; however, large amounts of aromatics may be produced from the lower straight-chain fractions by thermal cracking and cyclization over a catalyst. The temperatures are usually around or exceeding 600° C. Because of the large quantities of the lower paraffin available at low costs, these straight-chain saturated hydrocarbons have been widely studied for aromatization purposes, with attendant successful results. The pyrolysis of the lower olefines at temperatures around or exceeding 700° C. yields aromatics more readily, or at least to a greater extent, than the paraffins of similar molecular weight. It was found that in the case of ethylene pyrolysis, raising the pressure did not increase the yield; but it allowed reduction of 100° C. in the required temperature for the same yield for an increase of 10 atmospheres. Benzene, alkylbenzenes, and xylenes are separated out from these pyrolytic reactions. Benzene itself may be subjected to further thermal reactions in order to condense two molecules of benzene into one of diphenyl, which is of technical importance, as it can be used in heat-exchange media.

Diphenyl, together with toluene, ethylbenzene, and many other hydrocarbons, have been isolated also from the reactions attendant upon treating benzene with aluminium chloride. Treating alkylbenzene with the metal halide usually results in re-arrangement and fission of the side-chain, although a certain amount of dehydrogenation and condensation takes place. Treating toluene with aluminium chloride at the boiling point of toluene yielded benzene, methyl*cyclo*hexane, *m*- and *p*-xylene, ditolyl and dimethylanthracene. Ethylbenzene yielded benzene, diethyl-

benzene and triethylbenzene. Thus the possibilities of this type of reaction are numerous and varied.

The action of the halides themselves on benzene is either of the addition or substitution type; toluene and high homologues, however, give mostly substitution products, the halogen entering the side-chain or the aromatic nucleus, depending on the temperature, catalyst, and concentration of the reactants. Mono- and poly-chlorobenzenes are used industrially in the manufacture of sulphur-black dyes, phenols, *o*-dihydroxybenzenes, aromatic amines, diaryl ethers, and ketones. They have further uses as dielectrics and transformer oils, in the analysis of graphite greases, the dewaxing of hydrocarbon oils, the removal of carbon deposits from engine parts, the solution of paint and varnish, the preservation of wood, the destruction of insects, and the solution of refrigerants. Bromination and fluorination of benzene appear to proceed similarly to the chlorination of this hydrocarbon.

Chlorination of toluene yields benzyl chloride, together with other resultants. Benzyl chloride may be hydrolysed to yield phenolic compounds, as monochlorobenzene may be hydrolysed to yield phenol. Thus *o*- and *p*-cresol may be produced from heating monochlorotoluene in water to 300° C. with ammonia, cuprous oxide, and calcium hydroxide. Chlorocresols may be produced by reacting higher chlorotoluenes with alcoholic potassium hydroxide at 140–210° C. Benzyl acetate is produced from heating benzyl chloride with sodium acetate and acetic acid. Benzyl chloride may be mixed with a high-boiling distillate of coal tar to give a corrosion inhibitor for metals.

Further chlorination of benzyl chloride produces benzal chloride, the chlorination agent being nitrosyl chloride. Benzal chloride yields benzaldehyde on treatment with aqueous sodium sulphite. Again, by further chlorination, benzotrichloride is obtained, which may be used to give naphthalene sulphonyl chloride.

The aromatics which are so generally known for their uses as solvents, anti-knock fuels, and intermediary raw materials may be further studied with relation to oxidation processes. These studies are of interest both from an academic and a technical point of view. Thus, the oxidation of benzene appears to go in successive hydroxylations to yield phenol, hydroquinone, and finally quinone, after which step the ring appears to rupture. In the case of toluene and ethylbenzene the side-chain and the ring are oxidized simultaneously, giving in the case of toluene, dihydroxytoluene and benzyl alcohol simultaneously, the benzyl alcohol being further oxidized to benzaldehyde and benzoic acid; and in the case of ethylbenzene yielding dihydroxyethylbenzene and 1-phenylethanol simultaneously, the ethanol being further oxidized to acetophenone, benzaldehyde, and finally to benzoic acid.

Again, benzene may be oxidized to maleic acid catalytically, and this acid may be changed to the edible malic acid which is suggested as a substitute for tartaric acid. Maleic acid, on the other hand, may be reduced to succinic acid.

These are only brief glimpses of the vast number of aromatic compounds it is possible to generate from petroleum as a raw material.

cyclo*Paraffins.*

The proportion of *cyclo*paraffins occurring in many crudes is much less than that of aromatics or paraffins, and their isolation is very difficult. Consequently not so much is known about this class of hydrocarbons and their reactions as about the more abundant aromatics and non-cyclic compounds. However, enough is known about the characteristics of the lower members from *cyclo*propane to *cyclo*hexane to make their study both interesting and important.

The halogenation of the *cyclo*paraffins follows, more or less, similar lines of reactions as the halogenation of the paraffins, yielding the chloro- and bromo-derivatives. This similarity is particularly operative in the 5- and 6-membered rings: with the lower members of the series, such as *cyclo*propane and its homologues, halogenation not only gives a substitution reaction, but is accompanied with an addition reaction resulting in the rupture of the ring and the formation of halogenated straight-chain hydrocarbons. Thus, monochloro*cyclo*propane and 1 : 3-dichloropropane are produced when *cyclo*propane is chlorinated.

The most important member of this family is *cyclo*hexane, and thus with these preliminary remarks showing possible variations in the characteristics of individual members of the series, this compound will be studied as typical.

*cyclo*Hexane has been identified in certain crudes, and certain of its homologues have been found and isolated from distillation fractions of Russian, Eastern European, and American Mid-Continental crudes.

Catalytic dehydrogenation of *cyclo*hexane to benzene proceeds readily when nickel or palladium is used. The reaction, however, is not simple, and many by-products are produced simultaneously. In the purely thermal decomposition of *cyclo*hexane at atmospheric pressure and at temperatures of about 650° C. the main reaction products appear to be butadiene and ethylene, rather than benzene.

The action of aluminium chloride on this hydrocarbon is very interesting. In the reaction with acetylchloride in the presence of aluminium chloride the initial change appears to be one of dehydrogenation in which *cyclo*hexane behaves as a mixture of *cis*- and *trans*-isomers. The *cis*-form furnishes *cyclo*hexene, which is converted by acetyl chloride into tetrahydroacetophenone; and the *trans*-form is thought to proceed through a dicyclic system which would undergo fission to yield unsaturated radicles. Similarly, very interesting studies are afforded by the action of aluminium chloride on *cyclo*hexane in the presence of hydrogen chloride.

Chlorination of this hydrocarbon takes place when *cyclo*hexane and chlorine are exposed to diffused daylight, the chlorine displacing hydrogen in the ring. Mono-, di-, tri-, and tetra-chloro*cyclo*hexane have been prepared in this manner at low temperatures and without the use of catalysts. The chloro-derivatives then undergo reactions which are similar to those of the alkyl and aryl chlorides. Thus a Grignard compound may be obtained from the monochloro-derivative by treating it with magnesium in ether at 0° C. Similarly, bromo-derivatives may be formed into Grignard compounds with their important uses in organic chemistry. *cyclo*Hexane has been used as a reference compound in catalysis research and there is much data on its catalytic reactions.

The carboxylic derivatives of *cyclo*paraffins form the important group called "naphthenic acids," and these have found technical applications, particularly in the form of their alkali and heavy-metal salts. Naphthenic acids probably occur in all crude petroleums, the chief sources being Russian, Rumanian, and Polish oils. Although the content is usually between 0·1 and 2 per cent., it is estimated that even on the lower figure the potential world-annual production is 50,000 tons. They are usually extracted from petroleum by alkali wash; purification and production on a technical scale are, however, accomplished by various elaborate processes.

One of the uses suggested for these naphthenic acids is the breaking down of various types of oil emulsions, such as occur in the neutralization step following acid treatments of certain lubricating-oil distillates. On the other hand, emulsifying agents may be prepared from these very acids with sulphuric acid and its glycerol esters.

Artificial asphalts may be produced from heating these petroleum acids to 180° C. Insecticides and fungicides may be prepared by various methods from naphthenic acids. Again, esters of these acids have been recommended as plasticizers for cellulose esters.

Naphthenic or sulphonaphthenic acids are reported to increase the detersive power of soap solutions. The alkali soaps of the acids compare favourably with those of fatty acids with respect to foam-producing and emulsifying qualities, degrees of hydrolysis, and solubility in water. Due to disagreeable odours associated with them, however, their use as detergent materials has been limited. Deodorization of naphthenic acids is often very difficult. Emulsification properties as well as disinfectant and insecticidal qualities make these soaps very useful indeed.

The lead, cobalt, and manganese naphthenates are widely employed as driers in paints, and are reported to be more effective than the corresponding linoleates or resinates. Copper naphthenate is proposed as a component of priming coats intended as preservatives of wood. Metal salts of naphthenic acids have been used in the preparation of "extreme-pressure" lubricants. Many other uses of the metal salts of these petroleum acids exist, but sufficient has been said to indicate their variety and importance in modern life.

Sulphur Compounds.

Sulphur compounds are found in all crude petroleums, Pennsylvanian and Rumanian oils having minimum quantities, 0·03 per cent. or less, whilst others, like Mexican and Iraq crudes, having larger quantities, approaching 5 and more per cent. Practically all types of sulphur derivatives have been isolated from various distillate fractions, the chief types being elemental sulphur, hydrogen sulphide, mercaptans, thioethers, disulphides, and thiophenes. It will only be possible to detail certain applications of some of these compounds, as their reactions and possibilities are far too many even to be listed exhaustively.

Hydrogen Sulphide.

Being abundant, hydrogen sulphide provides a cheap and economical raw material for the manufacture of sulphuric acid, with yields as high as 98 per cent. The gas is burned in excess air to the dioxide and further

mixed with air or oxygen and converted into the trioxide of sulphur over vanadium, tin, or chromium oxides as catalysts. Absorption of the trioxide in water is all that is necessary to yield the vitally important sulphuric acid.

Other uses of hydrogen sulphide, or its alkali salts in particular, are of interest. The ripening of alkali-cellulose by air or gas containing oxygen is accelerated by the presence of an alkali-sulphide. Mild oxidation of the sulphides yields thiosulphates. Thus sodium hydrosulphide may be obtained from treating sodium sulphide with hydrogen sulphide at 300° C.

$$H_2S + Na_2S = 2NaHS.$$

Treating the hydrosulphide with air at 100–150° C. yields sodium thiosulphate.

$$2NaHS + 2O_2 \longrightarrow Na_2S_2O_3 + H_2O.$$

Various other methods exist for preparing this important compound from the sulphides. Again, an ore-flotation agent may be prepared from the interaction of rosin and hydrogen sulphide at 80° C. in the absence of oxidizing conditions.

Mercaptans and Others.

These sulphur compounds show certain acidic tendencies because they possess an –SH radicle. Their importance lies in the ability to react with many agents, such as with oxidizing agents like oxygen, sulphur, or halogens, to form disulphides; with aldehydes and ketones to form mercaptals and mercaptols respectively; and with acids to yield esters. Thus they are interesting intermediaries. Academically they offer valuable information on organic chemical reactions; their applications, however, are numerous as well.

Probably due to their great activity, they are used as oxidation inhibitors. Thus 1 per cent. of a mixture of amyl mercaptan and dibutyl amine can inhibit gum formation even in motor fuels obtained from cracked distillates. Insecticides and fungicides are prepared by incorporating mercaptans, admixed with phenols, with alkali polysulphides and an emulsifying agent; or simply by impregnating acid-treated fuller's earth or silica gel with mercaptans and disulphides. Disulphides or alkyl esters prepared from mercaptans may be used as accelerators in the vulcanization of rubber or flotation agents for ores. Sulphur bodies which possess detergent, wetting, and emulsifying properties may be prepared from mercaptans as a starting material. Further, softening agents for textiles may be produced from the combination of mercaptans and esters of chlorinated carboxylic acids.

Thioethers and polysulphides have been suggested as ingredients for fumigants and as solvents for rubber. Benzyl sulphide inhibits the corrosion of aluminium by hydrochloric acid. Derivatives of thioethers have been suggested for use as decolorizing agent for textile, as loosening agents for carbon deposits, and for the extraction of naphthenic hydrocarbons from mineral oils. Disulphides mixed with mercaptans or thioethers furnish flotation agents for copper ores; while tetrasulphides are said to accelerate ignition in diesel engines.

Sulphonic Acids.

As a result of sulphuric-acid treatment of petroleum products, a large group of compounds known as sulphonic acids is obtained. These products were formerly wasted as "acid sludge," but with increasing knowledge of their nature and usefulness an increasing number of individual products is now available for specific utility.

The mechanism of sulphonation is only known accurately in the case of the reaction of hydrocarbons of lower molecular weight. As it appears that the saturated hydrocarbons in the higher distillates of many oils are much more reactive towards chemical reagents, including sulphuric acid, than the lower-molecular-weight compounds, only inferences can be drawn regarding reactions which are of immediate interest to the petroleum chemist. Oleum or gaseous sulphur trioxide may be used to sulphonate oils; liquid sulphur dioxide extract layers from oils are found to be practically wholly composed of sulphonatable constituents. The sulphonic acids are removed, after sulphonation, either by selective solvent action of lower monobasic alcohols or by precipitating their salts by salting out.

Petroleum sulphonic acids are mildly detergent, being stable in hard water, acid, or alkaline solutions. The detergent action is enhanced by mixing the sulphonates from acid sludges with an alkali metal alkyl hydrogen sulphate of more than ten carbon atoms per molecule.

Sulphonic acids may also be used in making stable hydrocarbon emulsions, or, conversely, as constituents of emulsion-breaking mixtures. The emulsifying agents are useful in textile and leather work, whilst the emulsion-breakers are used in breaking the water-in-oil type of emulsion in petroleum production.

Further, a suggestion for using sulphonic acids from petroleum is their use as wetting agents for textiles in dyeing operations, particularly when dyeing from acid baths. Again, these sulphonates have been used as media for carrying protective lubricants for use on yarns.

The sulphonates of petroleum have several advantages as a wetting agent and vehicle for insecticides. Thus, for instance, they are more toxic when mixed with mineral oil than nicotine sulphate mixed with casein in hard water.

Of the miscellaneous uses of petroleum sulphonates, only a few need be mentioned to illustrate their wide scope and nature. They may be used in softening leather, as solvent activators to speed the mastication of rubber, or as a thermoplasticizing compound for use with rubber, in the manufacture of extreme pressure and other special lubricants, in the manufacture of polishing compounds, in making oil-soluble dyes from water-soluble dyes, in combination with fatty acids to prevent foaming in emulsions, in making fat-denaturants, in preparing medicinal products, in forming catalysts for esterification processes, in making resins applicable in varnishes and lacquers, and in making brushless shaving-creams. Many other varied uses could be mentioned, but full details of these operations and utilities can only be obtained from more comprehensive texts on the subject.

Nitrogen Compounds.

The nitrogen content of most petroleum oils is low, in the majority of cases not exceeding 0·1 per cent. However, considering the large quantities of oil produced, this figure is not a negligible quantity.

The nitrogen compounds existing in petroleum oils appear to be more complex than the pyridine homologues of the shale- and coal-oil nitrogenous substances. Petroleum products appear to be more of the hydroaromatic types of molecules. Thus, the nitrogen-containing compounds derived from petroleum are called naphthenic bases. The structure of many of these nitrogen bodies is unknown, probably because they break down during ordinary distillation and refining operations. It is known, however, that they are complex and are probably closely related to the alkaloids.

Uses of petroleum bases are as pickling inhibitors, insecticides and germicidal preparations, and inhibitors in the autoxidation of lubricating oils.

Recent work on the direct nitration of the lower members of the paraffins has been of considerable interest, as these members were, and are still, considered as most inert bodies towards reagents. Direct nitration in the vapour phase of all the lower members, excepting methane, of the paraffins resulted in yet another group of nitrobodies from petroleum as a raw material in 1933.

Low-molecular-weight alkyl nitrates and nitrites are well known for their use as ignition promoters in diesel-engine fuels. Certain fuels have been nitrated directly, instead of being doped with these nitrobodies, and were found to improve in their quality as diesel fuels. Again, a mixture of nitromethane, benzol, and ethyl alcohol has been found effective in removing carbon deposits from I.C. engines. Nitropropanes and nitrobutanes have been found to be good solvents for lacquer. Nitrated petroleum fractions have also been used in producing resins, dyes, plasticizers, and intermediates in the production of motor fuels. Nitrating toluene obtained from petroleum results, of course, in the well-known T.N.T. explosive.

Conclusion.

This review reveals a vast field of human knowledge, experience, and needs, and also emphasizes the importance of the subject of chemistry in its broadest sense and its relation to the utilization of petroleum products.

We, as a nation, have not risen to the responsibilities of our civilization as we might have done, in the manner in which we have promoted and encouraged the development of scientific knowledge.

The neglect of science spells waste and industrial decay, and those industrial nations which not only do not keep abreast of modern thought and development in the world of science, but, what is more important, do not take the lead, must surely and rapidly decline in prosperity.

We have most certainly not led the world in synthesis in so far as those fields of study which find their raw material in petroleum are concerned, although a number of isolated problems are being nibbled at in various

institutions, many of which are uninspired by anything beyond a desire for a University Mastership or Doctorate.

It is most essential for the prosperity of the British Petroleum Industry and this country that there should be organization, collaboration, and co-ordination of such research on the subject as subdivided in this paper, and equally essential that it should be controlled by those with specialized knowledge of the multitudinous possibilities before us. Although some of the investigations mentioned are of immediate concern, the majority are long-distance problems, but they should not be shelved longer than absolutely necessary because of this, despite the present emergency, if we, as a nation, are to reach the forefront of petroleum science.

After the last war, it was the hope of many that the vital dependence of our social and national prosperity on a knowledge and appreciation of the facts and principles of science, and on their application in industry, would be fully recognized, yet the scientific world has witnessed an appalling waste of natural resources since then.

It cannot be expected that one industrial organization, or even a group, should bear the responsibility, financial or otherwise, of developing comprehensive research on the lines indicated, however great the interest in such a scheme might be, particularly as we must beware of interpreting the usefulness of such work at the start, in the too narrow spirit of economic utility.

Although we have practically no indigenous source of supply of petroleum to speak of in Great Britain, and as an Empire we may lag behind other countries, through no fault of our own, as oil producers, nevertheless the amount of petroleum for which British capital is responsible is a very large proportion of the total available, and the scientific utilization of such a mineral and its many products can be said to be as important to us as that of coal.

We are spending anything up to £12 million a day to win the present war; could not a very small proportion of our war expenditure be allocated to experimental science, in order that we may also win the next peace, and so become the true benefactors to humanity by a more peaceful method, and one which would be less costly in its fullest meaning?

In other words, synthesis in its true understanding.

THE INSTITUTE OF PETROLEUM.

LUNCHEON.

THURSDAY, 1ST MAY, 1941.

A Luncheon of the Institute of Petroleum was held on Thursday, 1st May, 1941, at the Connaught Rooms, Great Queen Street, London W.C. 2. The PRESIDENT (PROFESSOR A. W. NASH) presided, and those present included :—

Mr. Geoffrey Lloyd, M.P. (Secretary for Petroleum), Sir Cecil H. Kisch, K.C.I.E., C.B., Sir Frank E. Smith, G.B.E., K.C.B., F.R.S., Sir Henry T. Tizard, K.C.B., F.R.S., Sir Alfred Faulkner, C.B., C.B.E., Dr. R. E. Priestley, M.A. (Vice-Chancellor, the University of Birmingham), Mr. F. C. Starling, Major G. P. Bulman, Mr. E. E. Soubry, Hon. M. R. Bridgeman, Mr. J. E. Montgomery, Mr. C. G. Burton, Mr. M. B. Donald, Dr. A. J. V. Underwood, Lt.-Col. S. J. M. Auld, O.B.E., Mr. T. Dewhurst, Dr. A. E. Dunstan, Mr. J. Kewley and Mr. T. Outen.

After the loyal Toast had been honoured, MR. T. DEWHURST (Past-President) proposed the Toast of

"HIS MAJESTY'S MINISTERS."

MR. T. DEWHURST (Past-President) said :

It is a great honour and privilege to be entrusted with this toast, for in these grave times His Majesty's Ministers represent all political parties and the whole nation, and offer the only hope for the deliverance and security of all enslaved and free peoples.

Two of the great speeches of recent times consisted of one sentence each. His Majesty the King visited a bombed area, when a spectator said to him, "You are a great King," and His Majesty replied, "And you are a great people." It is an axiom that a people gets the Government it deserves, and this great people and His Majesty's Ministers compliment each other.

The axiom casts a sinister light on the character of the German people. When one contemplates the Nazi leaders—those grotesque specimens of race purity—one is reminded of a recent dictum in regard to them. The dictum runs as follows: "It would require a special dispensation of Providence to raise them to the lowest level of human degradation." But whatever the German people may be, they certainly are not a race of Nordic supermen. They are about 40 per cent. Nordic and about 60 per cent. Alpine, whereas the people of the United Kingdom and Northern Ireland are about 75 per cent. Nordic and about 25 per cent. Mediterranean, so that even a Nazi ethnologist should be in no doubt as to which of these two peoples is the more fitted to survive in the present struggle for existence.

The late Lord Curzon said that in the last Great War "the Allies floated to victory on a sea of oil," and nothing could express so vividly the vital importance of petroleum products in modern warfare. When we contemplate the stupendous task of supplying petroleum products to the Navy on the seven seas, and to the Armies and Air Forces in this country, in the Mediterranean, in Libya, and Abyssinia, not to speak of the civil requirements of various countries, we realize how deeply indebted we and the whole nation are to the great Service Departments of State, to the Petroleum Board, and above all to the Petroleum Department and the Minister who is in charge of its activities. The victories of the Navy, notably that of the battle of Cape Matapan, the many victories of the Air Force, notably that of the Battle of Britain, the wonderful victories in Africa, and the gallant rearguard action in Greece—in all these engagements the adequate supply of petroleum products has been an indispensable condition

of success, although in the case of the Italians we have doubtless been helped by their lack of "abdominal fortitude"!

In view of the vital importance of petroleum products in this war it is a fortunate circumstance that we have a perfect organization for the supply of these products to our armed forces in all the various theatres of war, and experience has amply confirmed the great wisdom of the Government in deciding to create the Petroleum Board. It is hoped that the time will come when the Nazi war machine will run down owing to a shortage of petroleum products, and many people believe that this will prove to be the weakest link in their chain of essential supplies. However, the Nazi Blitzkriegs on Poland, Norway, Holland, Belgium, France, Yugoslavia, and Greece were of brief duration and may not have caused serious depletion of their oil reserves, but perhaps we may hope that as a result of our unceasing attacks by air on tanks, refineries, coal-oil plants, and on vital links in their transport system, the Nazis in due course will be incapable of sustaining a prolonged period of total war. We would welcome enlightenment on this important subject, but our hopes of obtaining this from an authoritative source are somewhat dimmed by the political experience and discretion of our chief guest.

The Royal Society as such was formed in 1662, and throughout its existence has advised Governments on scientific matters. The geologists broke away in 1807, and were followed by others who formed their own scientific societies, yet none of these has been privileged to advise Government on its own special subject. A later development was the formation of professional and technical societies and institutions, covering subjects such as civil, mechanical, marine, electrical and chemical engineering, the chemical industry, iron and steel, mining and metallurgy, petroleum, etc. These scientific and technical bodies include many thousands of members who have had a thorough scientific training, reinforced by years of practical experience in their respective subjects. Yet so essentially conservative—I use the word in a metaphysical and not a political sense—is the English character that the Royal Society, which is the scientific analogue of the Bank of England, remains the sole unofficial scientific adviser to the Government and holds aloof from all other scientific societies and institutions. This subject was raised and debated in the House of Lords a few weeks ago, and the Government spokesman, Lord Hankey, made the following statement: "The Government were at present in close touch with the professional societies concerned with a view to the possible establishment of a separate organization working in the field of applied science and in close touch with the Scientific Advisory Committee and an announcement might be expected before long." An official announcement was made yesterday in regard to engineering, and this Institute would welcome wholeheartedly any further developments in this direction which would lead to greater use being made of the knowledge and experience that it represents.

The House of Lords debate doubtless originated with the Parliamentary and Scientific Committee, an unofficial liaison body between professional societies, including this Institute, and Parliament. It is one of the duties of this Committee to arrange for questions to be put to His Majesty's Ministers on scientific and technical matters, and therefore it is potentially able—may I say, Abel to raise Cain? Notwithstanding this position, the Secretary for Petroleum has not yet been asked a single question as a result of those activities, as we are too well aware of the scientific and technical perfection of the Department under his control.

One of the major tasks carried out by this Institute during its history was the initiation and foundation of the World Petroleum Congress. Congress activities are now in abeyance, but it is certain that they will revive. This great Congress could not have been established without the help of His Majesty's Ministers. Indeed, the first page of the *Proceedings* of the first Congress contains the following statement: "From the outset the Congress had the approval of His Majesty's Government. The Secretary of State for Foreign Affairs, the Secretary of State for the Colonies, the President of the Board of Trade and the Secretary for Mines signified their approval by accepting nomination as Honorary Presidents, while the Secretary of State for Scotland represented the Government at the Congress Banquet. The Foreign Office through its representatives invited the Governments of foreign countries to send delegations. The Government also entertained delegates at an official reception at Lanchester House and at an official luncheon at the Hyde Park Hotel. In addition the Congress Committee was strengthened by the inclusion of the Director of the Petroleum Department

of the Board of Trade." This record alone demonstrates the great indebtedness of this Institute to His Majesty's Ministers, and we can only hope that the scientific and technical publications of the Institute have been of some slight service to the great Departments of State under their control.

It is a source of great pleasure to us to be able to couple this toast with the name of Mr. Geoffrey Lloyd. The early manifestation of Mr. Lloyd's qualities is proved by the fact that at the age of 27 he had been President of the Cambridge Union, Private Secretary to Sir Samuel Hoare, and was Private Secretary to Mr. Baldwin. As Private Secretary or Parliamentary Private Secretary to Mr. Baldwin for six years he must have been entrusted with many matters of high importance. Unfortunately, this experience deprives us of any hope that he will thrill us with any revelations which, however fascinating for us to hear, would be in the smallest degree impolitic for him to impart. While Parliamentary Under-Secretary to the Home Office he was responsible for the organization of the A.R.P. Services. During his tenure of office as Secretary of Mines he impressed the country by his frequent visits to the coal mines in search of information at first hand. It is unfortunate, therefore that we have not in this country about half a dozen big oilfields, particularly as truth is said to lie at the bottom of a well. Mr. Lloyd is the first Secretary for Petroleum in our history, and at a time when petroleum is recognized as a vital necessity for the survival of this country and Empire. We offer him our best wishes in his great task, and hope that a future historian will be able to say, again to quote Lord Curzon, that under his guidance this country once more floated to victory on a sea of oil. In view of Mr. Lloyd's heavy responsibilities and manifold duties at the present time, we deeply appreciate his presence here at the first function we have held since his appointment. I have pleasure in inviting you to rise and drink to the health of His Majesty's Ministers, coupled with the name of Mr. Geoffrey Lloyd. (*Applause.*)

Mr. Geoffrey Lloyd, M.P. (Secretary for Petroleum), in replying to the Toast, said :

It is a great honour to reply to this toast, but I am not going to be inveigled into any indiscretions. There are so many men in this room engaged so closely in secret work connected with armament and other vital industries in the war production of this country, that I doubt whether any other body of men that could be gathered together at this particular moment are aware of so many of the war secrets. There is therefore no need to talk about them at all. There will come a day when victory has been won and when we shall be able perhaps to exchange with each other some of the things we know.

We are all aware that oil is the motive force of modern war. It drives the ships of the navy, it drives the aeroplanes and the mechanized forces of the army, and in addition it provides the essential of power for a tremendous proportion of what is called the civilian war effort—an effort which, as we well know, is absolutely vital to the war effort as a whole. If the Government is entitled to credit in this matter, I think it is on the ground that it has had the sense to realize that in this country and the Empire we have an efficient oil industry and to take full advantage of the wealth of technical and business ability which is in that industry, also, from the point of view of supply, in making full use of the great organizations of the Petroleum Board. I am very glad to see Mr. Soubry, the representative of the Board, here to-day. I am not going to elaborate that point, but I think it was very fortunate and very wise that in handling our petroleum supply problems we have been able to arrange for the industry in this country to be unified, and so to be able to play its full part in a corporate capacity. So far every important and vital demand for oil for our war effort has been met, and in addition to the obvious thing that we all think of from the point of view of the armed forces, I would like to mention that, for example, the ploughing-up campaign of the Ministry of Agriculture has resulted in the largest demand for vaporizing oil for tractors ever known in this country. The industry has co-operated most efficiently with the Ministry in supplying these demands.

All these things have naturally required increased quantities of petroleum products. We are delighted that that should be so, that our military forces should have expanded so greatly as to require very much increased quantities of oil. The civilian private-car owner ever since the beginning of the war has made a great contribution by reduc-

ing his demand for the use of petrol in private cars, so that these other greatly increased needs might be met. Ever since the war began I have pleaded for economy in the use of petrol by the private-car owner, and the private motorist has made a very great response. But I do take this opportunity once again, as I do whenever I have the privilege of making a public speech, to re-affirm the need for economy by the private motorist in the use of petrol, and to remind those who have supplementary rations that those rations are only intended and allowed to be used for the essential purposes for which they were given. The Divisional Petroleum Officers have instructions to pay the strictest attention to that point.

I am not going to make a long speech to-day, and I merely wish to thank you very much for giving me the opportunity of meeting you and for the work that you are doing in connection with the war effort. I want you all to realise that those who are engaged in maintaining the oil supplies of this Empire and in perfecting the high quality of the petroleum products needed in the war effort are playing a great part in the battle as a whole. I hope that all our efforts will be as successful in the future as they have been in the past, and that the time may not be too distant when we shall be able to repeat the words which the last speaker quoted from Lord Curzon, that this country floats to victory on a sea of oil. (*Applause.*)

"The Institute of Petroleum."

Dr. R. E. Priestley (Vice-Chancellor, the University of Birmingham):

I have perhaps one or two qualifications which entitle me to propose the health of the Institute, not because I am a capable speaker, but because I have the honour of being Vice-Chancellor of the University which has one of the oldest Departments of Oil Technology and which in Lord Cadman and your President, Professor Nash, has had on its staff two of the greatest of British oil specialists. The second reason why I have some title to speak harks back to the distant past. Oil owes a tremendous lot to the geologist-explorer, and in my earlier days that is what I happened to be. It is true that most of my geology was done on the one continent where no oil has yet been found. I have a Cambridge friend who volunteered to drink all the oil that would be found in Britain. If he has attempted to fulfil his pledge, he must be suffering severely from indigestion to-day. I still feel, however, that I should be quite safe if I were rash enough to make a similar offer about Antarctica, where nearly all the country, except batches of the most recent volcanics, is covered by several thousands of feet of ice.

Scientific and technical associations are passing through difficult times to-day. Meetings of all sorts are not easy to arrange, travelling has to be cut to a minimum, and many of their members are not able to spare time from other work of national importance. It is one of the inescapable handicaps of democracy that it is not easy for these Institutes, which pride themselves first and foremost upon being free associations of individuals, to find their niche, as associations, in the national effort. This is bound to lead to a sense of frustration. Our societies have never been regimented or State-controlled. They have retained liberty of action and freedom of discussion, and above everything else they value the right of criticism. From time to time they have impressed upon reluctant Governments the claims of science, and it follows that they are not easily converted into Government Departments to play the rôle which similar associations play in the totalitarian States.

It is true that I am here as your guest, but also in a sense I am your war-time host, because the offices of the Institute have been housed at Edgbaston on the University site since September 1939. I do not know how far it is due to your presence that the University has recently received certain weighty presents from Hitler. You gentlemen have certainly made the world more interesting, though rather more uncomfortable in recent years. I give you my best wishes for the future. I bear in mind the fact that while the product with which you deal has greatly assisted men's powers of destruction it can equally, and in as great a measure, be applied to the reconstruction that must follow. With that in mind I have the greatest pleasure in proposing the health and continued prosperity of the Institute of Petroleum. (*Applause.*)

PROFESSOR A. W. NASH, in replying to the Toast, and in proposing that of "Our Guests," said:

It is with very great pleasure that I respond to this toast, particularly as it has been proposed by my Vice-Chancellor, because it gives me the opportunity of thanking him publicly, on your behalf, for his kindness in giving us office accommodation at the University of Birmingham, and this I do very sincerely. It is quite obvious, he being my Chief, that I cannot eulogize him to his face, but I am indeed very grateful to him for coming here to-day. I know he is such a busy man at the present time, having so many duties to perform in addition to his normal University duties of finding a common denominator for all the difficulties of his colleagues which are as diverse as the subjects which they profess.

I am sorry that His Excellency the Prime Minister of the Netherlands was prevented from attending, as so many of us have such happy recollections of business trips, as well as pleasure trips, paid to his country and to friendships formed with many of his fellow-countrymen. I sincerely hope it will not be very long before we are visiting our friends in Holland once again.

I am also sorry that Mr. C. S. Wright, the Director of Scientific Research and Experiment at the Admiralty, could not be present, as he would have had much in common with Dr. Priestley, both having been explorers—indeed, I believe they were shipmates on one expedition—but more particularly because I wanted to tell him a story which he could have taken back to his Service colleagues at the Admiralty.

The story was told to me by one of my students who joined the Royal Navy just after the outbreak of this war and, after some training, was sent as a seaman wireless operator, to a trawler which had been taken over by the Admiralty. This trawler was one of a fleet of five which had belonged to a certain company, all of which had been built in a small German shipyard. The engines had been giving trouble, and so the skipper, who had been in the ship since she was built, and, for that matter, so had the crew, wrote a report to the Commanding Officer of the fleet, aided, incidentally, by the rest of the crew, particularly in regard to the spelling in the report.

The Commanding Officer was a young Sub-Lieutenant, R.N., with no knowledge of the history of the vessels under his command, and the report he received, after explaining the repairs necessary, finished up with, "I have the honour to submit therefore that this vessel be returned to her original builders for a complete overhaul."

In due course a reply came from the Sub-Lieutenant to the effect that the Admiralty had looked up the records of the trawler, and as she was built in a German shipyard, the skipper would proceed to such and such a yard on the East Coast for repairs and refit.

Attached to the official letter was a private note from the "one ringer," which read: "If you think this is damned funny, I don't, and neither did My Lords of the Admiralty." (Laughter.)

I will not weary you with a long account of the Institute's proceedings over the last year. I always think such a procedure is most boring to the guests, who are not interested in our domestic affairs, and should not be necessary for the members if they have attended the meetings and read their journals regularly. We are still working under a considerable handicap, and our difficulties have not been lightened during this last year, due to reasons entirely beyond our control.

I feel I must pay tribute to the loyalty of our staff in this respect. They have worked splendidly. It is no easy matter these days, in an organization depleted of staff and the facilities which have previously been available, to keep the wheels running at all, but I can assure you, gentlemen, the wheels have been running much more smoothly than I ever expected.

Particularly would I mention our Secretary, Mr. Astbury, and the Assistant Secretary, Miss Tripp, and I would here say that this lady is also engaged in work of some importance in the Headquarters of one of our Civil Defence Services, in addition to her professional work.

As I have to address you again later, I will not make any further reference to the Institute's affairs at this stage, other than to say how very sorry we are not to have with us on this occasion one of our most distinguished Past-Presidents, Lord Cadman, who is, unfortunately, indisposed. I am sure you will all join with me in wishing his Lordship a speedy recovery, and I propose, with your agreement, to despatch a telegram expressing these sentiments. (*Applause.*)

Gentlemen, we have with us today a number of distinguished guests, and as they are all engaged on work of the greatest national importance, and will be anxious to return to their duties with as little delay as possible, your Council decided to cut the number of speeches to a minimum, hence the reason why I am responding to, and proposing, a toast at one and the same time.

We have important representatives of the Industry and of the Institution of Chemical Engineers, whom we are very pleased to see here today. Perhaps I may take this opportunity of thanking the President and Council of that body for their kindness in giving us the use of their Council Chamber for our Council Meetings in London.

I am also pleased to be able to welcome here today Mr. Soubry, who has succeeded my old friend Mr. Wolfe with the Anglo-American Oil Company.

Of the Minister for Petroleum you have heard already from one of our Past-Presidents, Mr. Dewhurst, so, beyond extending to him a hearty welcome, I will content myself with asking that he will do me the honour of reading the conclusions to the second Presidential Address which I am to give this afternoon, a copy of which I have handed to him. I would assure the Minister that this has been passed by the Censor.

The Petroleum Department, which, I think you will agree with me, is entrusted with one of the most important tasks associated with the war effort, is well represented, in that not only have we the honour of the presence of the Minister, but also Sir Cecil Kisch, the Director-General of the Department, who gave us such an excellent speech last year. We have also from the same Department Sir Alfred Faulkner, one time Director of Sea Transport, who has, consequently, a considerable knowledge of shipping, including oil tankers, and who is now Under-Secretary for Petroleum and Chairman of the Executive Committee responsible for investigating all oil questions.

The Hon. Maurice Bridgeman and Mr. F. C. Starling are so well known to us that I am sure they will forgive me if I cull an expression from the recent broadcast speech of Lord Beaverbrook, and describe them as two of the more senior "boys," but very important "boys," in the back rooms of the Petroleum Department.

When I come to Sir Frank Smith, I have to pause. I think everyone pauses when they come to Sir Frank. To give you a cavalcade of his scientific career would be an education in itself, for he is one of the most versatile scientists we have at the present time. From the Electrical Department of the N.P.L. he passed to the Admiralty as Director of Research, then transferred to the Department of Scientific and Industrial Research as its Secretary, during which time he was also the Secretary of the Royal Society.

I regret that at this stage I must disappoint you. It is said that the higher you climb the farther you have to fall, and Sir Frank then fell from grace with a bump. He entered the Petroleum Industry! However, he is now staging a "come-back," as since the war he has been appointed Director of Instruments. For myself, my greatest admiration for him lies in the fact that he chose the city of my adoption, Birmingham, as his birthplace. In addition, Sir Frank Smith represents the Ministry of Supply, which body is housed in a certain building somewhere in England, the whereabouts of which I regret I must keep you in complete ignorance because of the Censorship.

One of the greatest difficulties with which, I should imagine, the scientists in the various Ministries have to contend, is to watch that square pegs are not fitted into round holes. Perhaps I may be forgiven if I remind them that there are still many pegs, both round as well as square, in the world of Science which have not yet been fitted into *any* holes—a state of affairs I find it difficult to believe could exist in any other belligerent country.

I now come to the gentleman who plays one of the original characters of "the boys in the back room" at the Ministry of Aircraft Production in that Machiavellian fantasia "Bigger and More Beautiful Bombs" written and produced by Lord Beaverbrook, a description of which was given over the wireless recently. If we knew Major Bulman better, we should probably find his hobby is butterfly collecting or piscatology. Anyhow, may their bombs never grow less, and Major Bulman's engines never stall. Perhaps I may add that we do not mind which room Lord Beaverbrook puts them in, but Major Bulman and his colleagues in the various departments of that very live Ministry certainly come out of the top drawer so far as we are concerned. (*Applause.*)

By this time you will be saying to each other, "By Jove, what a covey!" But that is not all, gentlemen.

I have left Sir Henry Tizard till the last, only because he is to respond to this toast.

Sir Henry has attended many of our functions in the past, he is an Honorary Member of the Institute, and, as you all know, I was associated with him for some few years on a publication which some reviewers did us the honour of describing as a monumental work.

As many of you know, Sir Henry has been interested in aeronautics all his life, for he was in the Royal Flying Corps in the early part of the last war, when he received the Air Force Cross—that was before flying men were provided with "umbrellas"—and later became Assistant Controller of Experiments and Research in the Royal Air Force. Although he has since been Secretary of the Department of Scientific and Industrial Research, and subsequently Rector of the Imperial College of Science, he has always played an important part in the scientific development of aeronautics. In fact, he has been Chairman of the Aeronautical Research Committee for some years now. It was but natural that he should be called upon by the Air Ministry to serve the country at the outbreak of war—indeed, it would have been a calamity had it been otherwise—since when he has transferred to the Ministry of Aircraft Production.

I have already referred to Lord Beaverbrook in theatrical language as the Author and Producer of the Play. Perhaps Sir Henry will forgive me if I describe him, in the language of the silver screen, as the Director of Technical Effects. That he is a wise administrator, an indefatigable worker, and a forceful but tactful leader, I have very good cause to know, and it is only to be expected that one of our most virile services should now claim him.

I believe I am right in saying that our fighting services encourage their scientific staffs to co-operate and collaborate to the fullest extent with their operational staffs. About a month back, Viscount Samuel raised in the House of Lords the question as to whether some of the Government Departments had not taken too narrow a view of the word "scientist," and suggested that with some of the appointments there was not a sufficiency of direct contact with the operational side of the subject, whether military, industrial, or agricultural.

Lord Hankey, in a most interesting review of the situation in reply, made it quite clear that the Government had spared no pains in forming a large number of committees, many of the members of which by now, I am afraid, will have forgotten they were working men of science and have become officials, but I was more perturbed to read that after this country has been at war for one year and eight months, the Government was only now getting in touch with the professional societies concerned, with a view to the possible establishment of a separate organization working in the field of applied science, and in close touch with the Scientific Advisory Committee.

Anyone with any knowledge of industrial conditions knows that the procedure adopted by successful industrial leaders has been to employ industrial scientists who are familiar with processes and their problems, and who, having recognized those problems as being such as to require research of a fundamental character, as distinct from industrial experimentation, invariably call in the pure scientist to help. The Government's policy in regard to many committees appears to be, under our present system of nationalization, a reversal of a policy which has hitherto worked so well under many successful systems of rationalization in the past.

Since I prepared these notes—in fact, only yesterday—information has been published in the Press to the effect that a new Government Committee to advise on engineering problems has been formed under the Chairmanship of Lord Hankey. As this is an engineers' war, the advisability of such a step is without question, and I am sure we are all pleased to see that this Committee is to have the benefit of the knowledge, experience, and advice of Sir Henry Tizard and Mr. H. R. Ricardo.

Perhaps I may conclude by telling you of a conversation I had with the Chairman of a certain committee which was formed about a year ago to investigate a subject of which I think I may claim to have some little knowledge. When he asked me what I thought of his committee, I replied that I thought it would have functioned much better if the members had a greater knowledge of their subject. To this the Chairman replied, "Yes, but look at the list of names on the Committee!"

Well, gentlemen, the guests I have introduced to you today, have been called to their important posts not because of their names, but because of their reputations, and I think we are very fortunate in having such men at the head of affairs at the present time.

I now give you the toast of "Our Guests," coupled with the name of Sir Henry Tizard. (*Applause.*)

SIR HENRY TIZARD, replying to the Toast, said:

I am the last speaker on your list, and my idea was to wait and pick up some gems in the rough that had been dropped by previous speakers, and see whether I could do anything in the way of polishing them. But the gems have been so well polished on this occasion that I am rather at a loss. I did, however, notice one gem a little in the rough which was dropped by Mr. Dewhurst. I understood him to say that His Majesty's Ministers offered the only hope of victory for democracy. No one, except possibly His Majesty's Ministers themselves, has a higher respect for them than I have, but that reminds me of the other old story of the man who was very ill and whose wife asked the doctor whether there was any hope. The doctor replied, "I have done everything I can; all we can do now is to trust in Providence," whereupon the wife said, "Is it as bad as that, doctor?" (Laughter.) If I were one of His Majesty's Ministers it would horrify me to be told that the only hope of victory rested on me and my colleagues. The hope of victory lies in the courage of the people of this country and in this country's scientific and technical resources. Is it not significant that we have a Prime Minister who never tells us to be courageous, but always assumes that we are?

Everybody knows the tremendous importance of petroleum in this war. The fact is that this is a war of mechanical power, and the great technical problem is to know what types of engines are made and to use them in the right way, and the using of them in the right way is not the simplest part of the problem. The last war, from a scientific point of view, was a chemist's war, and this might be called a radio war. There is more demand for radio scientists in this war in proportion to the number available in peace-time than in any other branch of science.

I went to America last September, and I should like to tell you something about that. We have got a lot to face now, and we are going to have a lot to face in the future, but it is of interest to realize some things that have happened, and especially the tremendous prestige which this country has gained for its courage—the courage of the ordinary common man and woman. But what is not quite so well realized is the tremendous technical prestige we have now. I have not a grasp of everything that has happened on all sides of the war effort, but I do know something about my own particular branch, and, with possibly one exception, I do not know of any single field of which we can say that another country has surpassed us in scientific and technical merit. (*Applause.*)

The proceedings then terminated.

VISCOSITIES OF HOMOLOGOUS SERIES AT EQUAL TEMPERATURES.*

By A. H. Nissan, Ph.D., and A. E. Dunstan, D.Sc.

Viscosity is a strongly constitutive property, but it was early found that the logarithmic function of viscosity was additive in many hydrocarbons over a certain range of molecular weight. Thus, at a constant temperature,

$$\log \mu = A \text{ (molecular weight)} + B,$$

for an homologous series.

However, even in the very early stages of these studies (1914), it was reported that "The tendency of the members of highest molecular weight to depart from linearity . . . shows that not only must the gross effect of each CH_2 be considered, but also, perhaps, its percentage effect, which, of course, will become less as the molecular weight increases." In other words, notwithstanding the remarkable similarity in the values of $\Delta \log \mu$ for the increment of molecular weight of CH_2 as calculated from various series, such as normal paraffins, alkyl iodides, ethers, esters, ketones, etc., yet in any one series if the range of molecular weight of the members be extended indefinitely upwards the value of $\Delta \log \mu$ appears to decrease.

Recently an attempt was made to derive this additive law from semi-empirical considerations,[1] and it was found that in certain cases this deviation with higher molecular weights could be reduced if the law is rendered

$$\log \mu = A \log \text{ (molecular weight)} + B.$$

This improvement could not be attained in all series, and can therefore be taken to be only fortuitous. To illustrate both the constancy of $\Delta \log \mu$ over limited ranges of molecular weight and its variation over a wide

Table I.

Number of C in molecule.	Log μ in millipoises at 20° C.	$\Delta \log \mu$ for CH_2.	Average for $\Delta \log \mu$.
C_4	0·236		
C_5	0·364	0·128	
C_6	0·504	0·140	
C_7	0·614	0·110	
C_8	0·732	0·118	
C_9	0·851	0·119	
C_{10}	0·958	0·107	0·101
C_{12}	1·166	0·104	
C_{14}	1·337	0·085	
C_{16}	1·546	0·054	
C_{18}	1·656	0·055	

range, Table I is given for the normal paraffins from C_4 in the molecule up to C_{18}.

Table II gives the same results for the case of *n*-alkylbenzenes. The

* Paper received 6th February, 1941.

first members were omitted, as molecular shape factors enter into the results and complicate the analysis.[2]

TABLE II.

Number of C in side chain.	Log μ in millipoises at 20° C.	Δ log μ for CH_2.	Average for Δ log μ.
C_3	0·934		
C_4	1·021	0·087	
C_5	1·134	0·113	
C_6	1·239	0·105	
C_7	1·329	0·090	0·091
C_9	1·508	0·089	
C_{13}	1·748	0·080	
C_{14}	1·898	0·075	

To understand both the regularities and the anomalies exhibited, the significance of $\Delta \log \mu$ should be appreciated. The most useful and frequently attested formula connecting viscosity and temperature for liquids is :

$$\mu = A'e^{B/T} = A'e^{Q/RT},$$

where μ = absolute viscosity,
Q = energy of activation of viscosity,
T = absolute temperature,
and A', B, and R = constants.

Q is assumed to be a constant, when actually it varies with temperature. Its variation over, say, 100° C. for unassociated liquids is, however, negligible. Thus :

$$\log_e \mu = A + \frac{Q}{RT}.$$

For two liquids, being successive members of an homologous series, then at equal temperatures T,

$$\log_e \mu_2 - \log_e \mu_1 = \left(A_2 + \frac{Q_2}{RT}\right) - \left(A_1 + \frac{Q_1}{RT}\right)$$
$$= \left(\frac{Q_2 - Q_1}{RT}\right) + (A_2 - A_1)$$

Thus $$\Delta \log \mu = a(\Delta Q) + b(\Delta A)$$

ΔQ represents the excess energy required to drive the larger molecule through a hole in the liquid and is connected with molecular volume. The constant A was derived approximately by Eyring and his collaborators [3] and was found to be proportional to

$$\left(\frac{M^{\frac{1}{3}}T^{\frac{1}{2}}}{V^{\frac{1}{3}}Q}\right)$$

where M = molecular weight,
V = molecular volume.

As T is constant, and $Q = f(V)$, it is seen that (ΔA) is connected with molecular volume to a greater extent than with molecular weight. Thus, it may be concluded that an approximate equation for $\Delta \log \mu$ would be :

$$\Delta \log \mu = f(V).$$

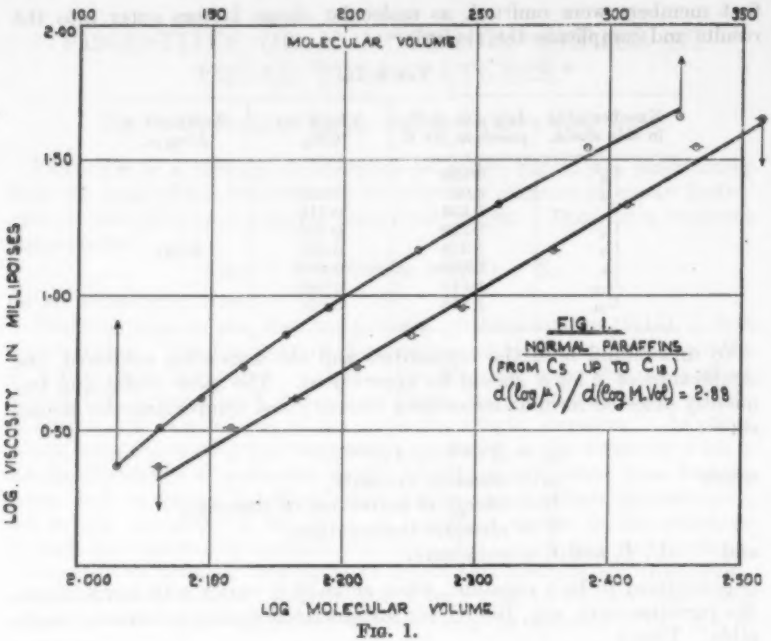

100
150
200
250
300
350
MOLECULAR VOLUME
2·00
1·50
1·00
0·50
LOG. VISCOSITY IN MILLIPOISES
FIG. 1.
NORMAL PARAFFINS
(FROM C5 UP TO C18)
d(log μ) / d(log M.Vol) = 2·88
2·000
2·100
2·200
2·300
2·400
2·500
LOG MOLECULAR VOLUME

FIG. 1.

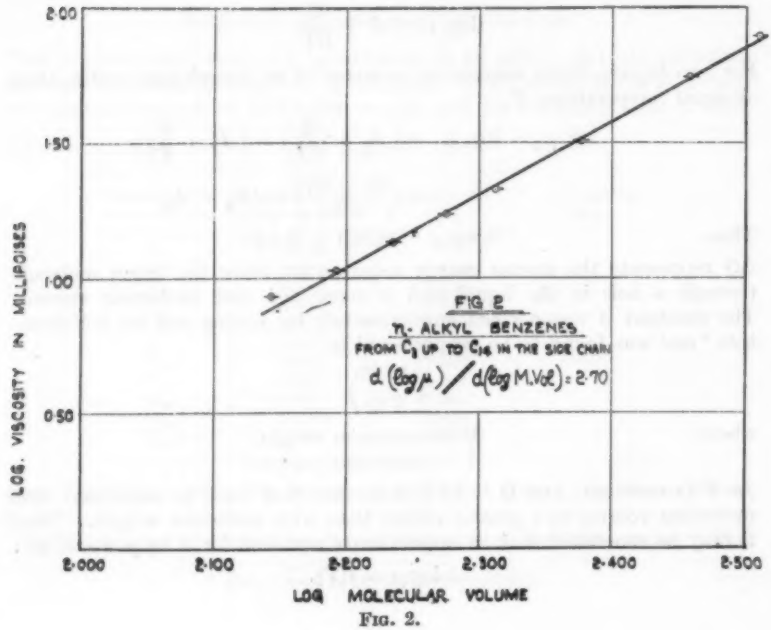

2·00
1·50
1·00
0·50
LOG. VISCOSITY IN MILLIPOISES
FIG 2
n-ALKYL BENZENES
FROM C3 UP TO C16 IN THE SIDE CHAIN
d (log μ) / d(log M.Vol) = 2·70
2·000
2·100
2·200
2·300
2·400
2·500
LOG MOLECULAR VOLUME

FIG. 2.

This equation suggests that a better relationship will probably result when $\Delta \log \mu$ is studied in conjunction with V than with M. To test this theory Table III was prepared and Figs. 1 and 2 plotted.

TABLE III.

Hydrocarbon.	V at 20° C.	Log V.	Log μ in millipoises at 20° C.
n-C_5H_{12}	114·9	2·0605	0·364
n-C_6H_{14}	130·4	2·1153	0·504
n-C_7H_{16}	146·2	2·1651	0·614
n-C_8H_{18}	162·2	2·2101	0·732
n-C_9H_{20}	178·3	2·2512	0·851
n-$C_{10}H_{22}$	194·4	2·2889	0·958
n-$C_{12}H_{26}$	228·0	2·3580	1·166
n-$C_{14}H_{30}$	258·9	2·4130	1·337
n-$C_{16}H_{34}$	291·6	2·4647	1·546
n-$C_{18}H_{38}$	326·9	2·5144	1·656
$C_6H_5{\cdot}C_2H_7$	139·2	2·1437	0·934
$C_6H_5{\cdot}C_6H_9$	155·4	2·1916	1·021
$C_6H_5{\cdot}C_6H_{11}$	171·7	2·2348	1·134
$C_6H_5{\cdot}C_6H_{13}$	188·4	2·2750	1·239
$C_6H_5{\cdot}C_7H_{15}$	204·8	2·3115	1·329
$C_6H_5{\cdot}C_9H_{19}$	237·8	2·3761	1·508
$C_6H_5{\cdot}C_{12}H_{25}$	287·0	2·4579	1·748
$C_6H_5{\cdot}C_{14}H_{29}$	319·8	2·5048	1·898

It will be seen from Figs. 1 and 2 that a straight line represents fairly the plots of $\log \mu$ against $\log V$, but, as expected from the analysis, a certain amount of curvature is evident due to the complex nature of $f(V)$ and to the effects of molecular weight and molecular shape. Again, the slope of the line for the n-paraffins is 2·88, as against 2·70 for the n-alkylbenzenes. Considering the wide range in molecular weight and the great difficulties in isolating pure normal paraffins of high molecular weights, the agreement appears to be as good as could be expected.

CONCLUSION.

It appears that $\log \mu$ is connected more directly with molecular volume than with weight. The formula:

$$\log \mu = A \log (\text{molecular volume}) + B$$

applies to a greater extent than the original

$$\log \mu = A \, (\text{molecular weight}) + B,$$

when a wide range of members of homologous series is considered. The molecular volume formula, however, is still far from being comprehensive.

Department of Oil Engineering and Refining,
The University, Birmingham.

References.

[1] Nissan, A. H., "Dunstan's Law," *Nature*, 1939, **144**, 383.
[2] Nissan, A. H., Clark, L. V. W., and Nash, A. W., *J. Inst. Petrol.*, 1940, **26**, 154–222.
[3] Eyring, H., *J. Chem. Phys.*, 1936, **4**, 283.

REVISED STANDARD METHOD OF TEST FOR DISTILLATION OF LIQUID ASPHALTIC BITUMEN (TENTATIVE).*

(CUT-BACK ASPHALTIC BITUMEN AND ROAD OILS.)

I.P.T. Serial Designation—C.B. 3–1941 (T).

A.S.T.M. Serial Designation—D. 402–36 (*modified*).

APPARATUS.

Flask.—The distillation flask, Fig. 1, shall be a side-neck glass distilling flask and shall have the following dimensions :

Capacity of bulb to base of neck	455 ml.	± 12 ml.
Diameter of neck, inside	25 mm.	± 1·2 mm.
Diameter of tubulature, inside	10 ,,	± 0·5 ,,
Height of flask, outside	135	± 5·0 ,,
Vertical distance bottom of bulb, outside to horizontal tangent at tubulature, inside	105 ,,	± 3·0 ,,
Length of tubulature	220 ,,	± 5·0 ,,
Angle of tubulature	75 deg.	± 3 deg.
Thickness of tubulature wall	1·0 to 1·5 mm.	

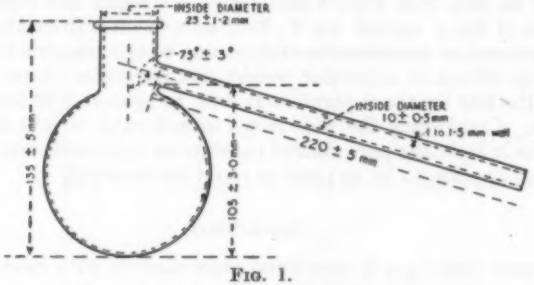


FIG. 1.

DISTILLATION FLASK FOR LIQUID ASPHALTIC BITUMEN.

Condenser.—This shall be a Liebig-type condenser having a water jacket 200 to 220 mm. long.† The actual condenser tube shall be a suitable form of tapered glass tubing of the following dimensions :

Outside diameter of small end	12·5 mm.	± 1·5 mm.
Outside diameter of large end	28·5 ,,	± 3·0 ,,
Length	360·0 ,,	± 4·0 ,,
Length of tapered portion	100·0 ,,	± 5·0 ,,
Thickness of walls	1·0 to 1·5 mm.	

* Revised March 1941.

† If preferred an air condenser of the same liquid tube dimensions as the standard water condenser may be used, provided that the operator is satisfied that no vapour loss will result.

Shield.—A galvanized iron shield, lined with $\frac{1}{8}$-in. asbestos, of the form and dimensions shown in Fig. 2 shall be used to protect the flask from air currents and to prevent radiation. The cover (top) may be of fibre board made in two parts, or it may be of galvanized iron lined with $\frac{1}{8}$-in. asbestos.

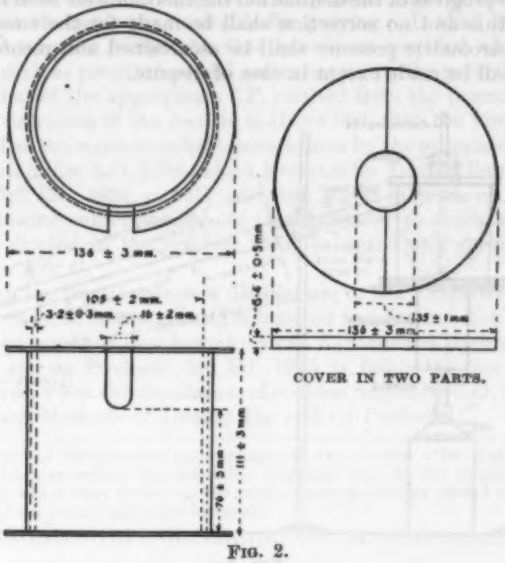


FIG. 2.
SHIELD.

Graduated Receiver.—The distillate shall be collected in a Crow Receiver, conforming to the British Standard Specification No. 605.

Thermometer.—The thermometer shall be the "I.P.T. High Distillation," and shall conform to the specification as laid down on p. 192 of Standard Methods for Testing Petroleum and its Products, 3rd Ed., 1935.

PREPARATION OF SAMPLE.

The sample, as received, shall be thoroughly stirred and agitated, warming, if necessary, to ensure a complete mixture before the portion for analysis is removed.

The material may be tested for distillation without dehydration if the amount of water present permits this. If water is present to such an extent that distillation is not practicable, the sample shall be dehydrated before distillation.*

METHOD.

The flask shall be supported on a tripod or rings over two sheets of 20-

* The dehydration may be effected by distilling the water from an amount of not less than 250 ml. of the material. Any light oils which appear in the distillate must then be separated and poured back into the flask when the bituminous material is sufficiently cooled. After thorough mixing, the amount required for the distillation test is taken, the results being recorded as for the dehydrated sample.

mesh gauze, 150 mm. square, as shown in Fig. 3. It shall be connected to the condenser tube by a tight cork joint. The thermometer shall be inserted through a cork in the neck and immersed in the sample with the bottom of the bulb 6·5 mm. ($\frac{1}{4}$ in.) above the bottom of the flask.

During the progress of the distillation the thermometer shall remain in its original position and no correction shall be made for the emergent stem. The actual barometric pressure shall be ascertained and recorded, but no correction shall be made except in case of dispute.

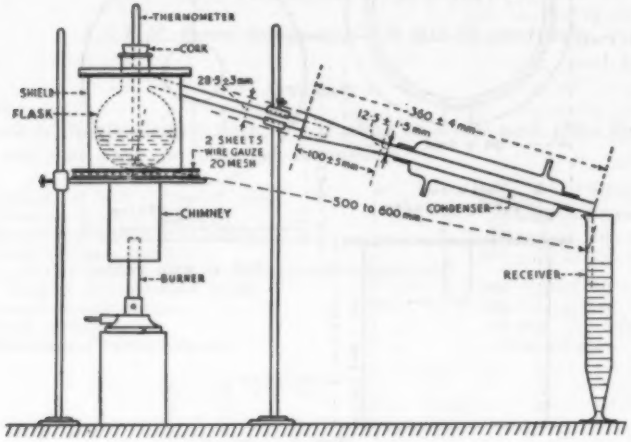


FIG. 3.

DISTILLATION APPARATUS ASSEMBLY.

The axis of the flask through the neck shall be vertical.

The distance from the thermometer to the outlet end of the condenser tube shall be not more than 600 nor less than 500 mm.

The burner shall be protected from draughts by a suitable shield or chimney (see Fig. 3).

The quantity of the sample to be used shall be 200 ml., and this amount shall be obtained by weighing the requisite quantity into the distilling flask, the weight being calculated from the specific gravity of the material at 60° F. When this amount has been introduced into the flask, the apparatus shall be assembled and heat applied, so that the first drop comes over in from 5 to 15 minutes. The distillation shall be conducted at the rate of between 50 and 70 drops per minute and the distillate collected.

The fractions to be reported shall be recorded in percentages by volume as follows :

Total distillate to	175° C.
" "	200° C.
" "	225° C.
" "	250° C.
" "	275° C.
" "	300° C.
" "	325° C.
" "	360° C.

When the temperature of 360° C. is reached the flame shall be removed and the residue allowed to cool to 300° C. without disconnecting the flask from the condenser. The residue shall then be poured into a tin 2½ in. in diameter by 3 in. deep, and shall be allowed to cool in a position free from draughts and without covering, to a temperature that is below its fuming point and at the same time suitable for pouring. It shall then be stirred and poured into the receptacles that have been specified when testing for properties such as penetration and softening point, the procedure employed following that of the appropriate I.P. method from the pouring stage.*

If the penetration of the residue is above 500, then the viscosity shall be determined at the recommended temperatures by the apparatus and method as laid down under L.O. 8 (Standard Methods for Testing Petroleum and its Products, 3rd Ed., 1935, p. 161) using the No. II instrument.

After allowing sufficient time for the condenser to drain, the volume of distillate collected in the receiver shall be noted and recorded as Total Distillate to 360° C.

If desired, the fractions from a distillation, or the distillates from parallel operations, may be combined and submitted to a further distillation by the apparatus and method laid down under G. 3 (Standard Methods for Testing Petroleum and its Products, 3rd Ed., 1935, p. 66) in the case of petroleum compounds or, when the distillate is of coal-tar origin, by C.O. 3 as laid down in "Standard Methods of Testing Tar and its Products."

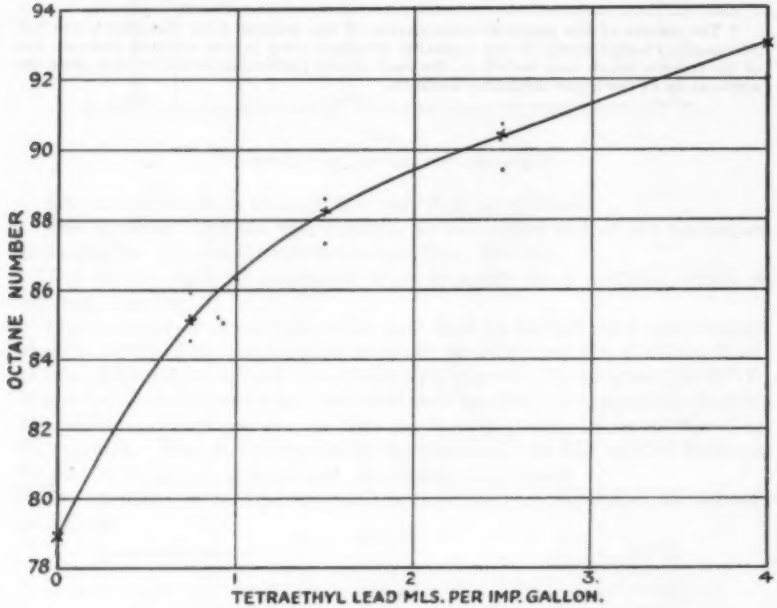
* The results of the physical examination of the residue after distillation are not necessarily characteristic of the asphaltic bitumen used in the original mixture nor of the residue which may be left on the road at any particular period of time after the application of the liquid asphaltic bitumen.

CALIBRATION OF TETRAETHYL LEAD IN STANDARD REFERENCE FUEL C.12 BY C.F.R. MOTOR METHOD.

REPORT OF THE INSTITUTE OF PETROLEUM KNOCK RATING OF AIRCRAFT FUELS PANEL SUB-COMMITTEE.

AT a meeting of the above Panel it was decided to prepare a calibration for T.E.L. in C.12 reference fuel. It was also agreed that primary reference fuels should not be employed in this instance, as two accepted sub-reference fuel calibrations were available for providing cross checks—namely, T.E.L. in C.11 and F.3 in C.12. Four concentrations of T.E.L. in C.12 were rated in twelve C.F.R. engines, owned by seven laboratories, thus providing twenty-four ratings for each point.

The test data are given in Appendix A, from which it will be seen that the maximum spread obtained on any point was 1·8 O.N. The average points have been plotted in the figure and a calibration table for laboratory use has been prepared.



CALIBRATION CURVE FOR C.F.R. MOTOR METHOD.
T.E.L. in C.12.
Prepared by the Institute of Petroleum, March, 1941.

Remarks.

The calibration curve is almost coincident with that of T.E.L. in C.11, varying by not more than 0·2 O.N. The disagreement with the C.12 calibration table prepared in America varies up to a maximum of 1·1 O.N. in the region of 86 O.N.—that is in the region of 1 ml. T.E.L./Imp. gall. concentration.

Octane Number Calibration Tables for Motor Method.
C.12 + T.E.L. (mls. per Imp. gall.).

T.E.L.	Oct. No.	T.E.L.	Oct. No.	T.E.L.	Oct. No.
0·00	78·9	1·20	87·2	2·40	90·2
0·05	79·4	1·25	87·4	2·45	90·3
0·10	79·9	1·30	87·6	2·50	90·4
0·15	80·4	1·35	87·7	2·55	90·5
0·20	80·8	1·40	87·9	2·60	90·6
0·25	81·3	1·45	88·0	2·65	90·7
0·30	81·8	1·50	88·2	2·70	90·8
0·35	82·2	1·55	88·3	2·75	90·9
0·40	82·7	1·60	88·5	2·80	91·0
0·45	83·1	1·65	88·6	2·85	91·0
0·50	83·5	1·70	88·7	2·90	91·1
0·55	83·8	1·75	88·9	2·95	91·2
0·60	84·2	1·80	89·0	3·00	91·3
0·65	84·5	1·85	89·1	3·10	91·5
0·70	84·8	1·90	89·2	3·20	91·6
0·75	85·1	1·95	89·3	3·30	91·8
0·80	85·4	2·00	89·4	3·40	92·0
0·85	85·7	2·05	89·5	3·50	92·2
0·90	85·9	2·10	89·6	3·60	92·3
0·95	86·2	2·15	89·7	3·70	92·5
1·00	86·4	2·20	89·8	3·80	92·7
1·05	86·6	2·25	89·9	3·90	92·8
1·10	86·8	2·30	90·0	4·00	93·0
1·15	87·0	2·35	90·1		

APPENDIX A.

Calibration C.12 + T.E.L.

Mls. T.E.L./Imp. gall.:	0·75.	1·5.	2·5.	4.
Engine A	85·0	88·5	90·6	—
	84·7	88·6	90·5	93·4
B	84·9	88·1	90·7	—
	85·1	88·6	90·3	93·2
C	85·1	88·2	90·4	—
	84·8	87·9	90·0	93·0
D	85·2	88·3	90·5	93·1
	84·9	88·1	90·0	92·8
E	85·5	88·3	90·6	93·8
	85·9	88·6	90·6	93·6
F	85·3	88·3	90·5	93·5
	85·4	88·5	90·2	93·3
G	85·4	88·4	90·5	93·1
	85·3	88·4	90·5	93·0
H	85·4	88·4	90·3	92·7
	85·4	88·2	90·3	92·8
I	84·9	88·2	90·4	92·8
	85·0	88·2	90·2	92·8
J	85·3	88·4	90·5	92·4
	85·1	88·1	90·2	92·5
K	85·0	87·9	90·6	93·2
	84·5	87·3	89·4	92·0
L	85·3	88·4	90·7	93·0
	85·2	88·0	90·3	92·5
Average octane number	85·1	88·2	90·4	93·0
Spread	1·4	1·3	1·3	1·8

Note.—The first rating on each engine was using C.11/T.E.L.; the second was using F.3/C.12.

TWENTY-SEVENTH ANNUAL REPORT.

1940.

THE Twenty-Seventh Annual Report of the Council covering the activities of the Institute during 1940 is presented for the information of the members.

MEMBERSHIP.

The changes in membership which occurred during 1940, and the total membership of all classes on 31st December, 1940, are summarized in the Table below :—

	Total Dec. 31, 1939.	Changes during 1940.							Total Dec. 31, 1940.
		New.	Transferred to.	Deceased.	Resigned.	Transferred from.	Removed.	+ or −.	
Hon. Members.	19	—	—	2	—	—	—	− 2	17
Fellows . .	406	11	2	5	2	—	2	+ 4	410
Members .	516	23	5	7	16	—	19	−14	502
Assoc. Mems. .	546	25	4	1	10	7	20	− 9	537
Students .	130	17	—	—	2	4	5	+ 6	136
Totals .	1617	76	11	15	30	11	46	−15	1602

The number of new entrants is considerably less than in recent years, but the main reason for the decrease in membership is the removal of 46 names. At the end of 1939 no names were removed from the Institute's register for reason of non-payment of subscriptions, but it has now been considered advisable to remove certain names in order to avoid giving a false impression of the growth of membership. It is confidently expected that many names now removed will be reinstated after the war.

The Council has to record with deep regret the decease of the following members during 1940 :—

	Date elected.	Class of membership.
ANFILOGOFF, N. A. . . .	1913	Fellow
BLAKE, D. M.	1935	Associate
CAMBI, V.	1933	Member
COSTE, E.	1917	Member
EDMED, F. G.	1932	Hon. Member
FRANCIS, C. K.	1927	Fellow
GROUNDWATER, W.	1920	Member
HADFIELD, SIR ROBERT A. . .	1929	Hon. Member
HENDERSON, J. A. L. . . .	1913	Member
HENNY, V.	1924	Fellow
HILLMAN, E. S.	1931	Member
KEITH, H.	1932	Member
LEA, F. B.	1919	Fellow
✝RHYS-PRYCE, M. A.ap. . . .	1934	Fellow
STRINGER, R. J.	1921	Member

✝ Killed on active service with the R.A.F. in France, June 1940.

Honours.

Mr. William Sigsworth (Associate Member) was among the first recipients of the award of the George Medal for conspicuous gallantry.

It is estimated that about fifty members of the Institute are serving with the Imperial Forces.

Representation on Other Bodies.

The Institute has been officially represented on the following bodies :—

The American Society for Testing Materials : Lt.-Col. S. J. M. Auld, O.B.E., M.C., Dr. A. E. Dunstan, Dr. F. H. Garner, and Mr. J. Kewley (Honorary Members of Committee D-2 on Petroleum Products and Lubricants).

The Parliamentary and Scientific Committee : Executive Committee : The President and Lt.-Col. S. J. M. Auld, O.B.E., M.C. General Committee : The President, Lt.-Col. S. J. M. Auld, Mr. T. Dewhurst, and Dr. E. R. Redgrove.

The British National Committee of the World Power Conference : Dr. A. E. Dunstan.

The British Standards Institution, Petroleum Industry Committee : Lt.-Col. S. J. M. Auld, O.B.E., M.C., Prof. J. S. S. Brame, C.B.E., Dr. A. E. Dunstan, Mr. B. J. Ellis, Dr. F. H. Garner, Mr. J. Kewley, and the Secretary.

Diesel Engine Users Association : Mr. L. J. Le Mesurier and Mr. N. Mitchell.

The Institute has also been represented on numerous sub-committees of the British Standards Institution. Various matters relating to new or revised specifications have been referred by the B.S.I. to sub-committees of the Institute's Chemical Standardization Committee.

Benevolent Fund.

The audited statement of Receipts and Payments of the Benevolent Fund during 1940 is submitted below. The receipts from all sources were £121 1*s.* 8*d.* as compared with £76 6*s.* 5*d.* in 1939.

Contributions to the Fund during 1940 were received from the following members, to all of whom the Council expresses its grateful thanks :—

Adams, A. C.
Auld, S. J. M.
Bailey, E. M.
Barrett, J.
Bell, O. A.
Blakiston, J. H.
Bolton, R. P.
Bressey, R. J.
Brodie, N. M.
Brown, C. B.
Brown, R. G.
Bushe, L. A.
Cameron, I.
Carter, A.
Castle, A. F.
Chadwick, A. (decd.).
Charlton, H. E.
Chrisman, A. E.
Clement, L.
Clifford, G.
Cohn, T.
Cole, F. A. J.
Connor, W. W.
Cox, A. W.
Coxon, G. H.
Crichton, R.
Cuthill, J.
Dalley, C.
Darley, H. C. H.
Dick, A. E.
Dodds, E.
Downs, W. W.
Dunkley, G. W.
Dunstan, A. E.
Edeleanu, I.
Egloff, G.
Elliman, S.
Evans, E. B.
Everist, G. E.
Fay, E.
Fletcher, H. D.
Garner, F. H.
Gascoigne, G. N.
Godfrey, R.
Greenwood, W. A.
Griffiths, P. M.
Hartley, A. C.
Heath-Eves, H. B.
Henson, F. R. S.
Hirst, W. P.
Hotham, E.
Howard, G.
Jackson, J. S.
Jameson, J.
Jennings, J. C.
Kamen-Kaye, M.
Kenyon, H. F.
Kewley, J.
Knights, J. W.
Kugler, H. G.
Lavington, H. V.
Le Mesurier, L. J.
McCreath, T. T.
Mackilligan, R. S.
Macniven, H.
Masters, J. S. S.
Mayo, H. T.
Moon, C. A.
Nash, A. W.
Owen, A. G.
Owen, R. M. S.
Perks, A. J.
Porter, P. N. D.
Pracey, H. E. F.
Purves, A. R.
Redgrove, E. R.
Reid, H. W.
Richard, A. H.
Richards, G. A.
Robathan, T.
Roger, A.
Ruthven-Murray, A. J.
Sams, C. E. R.
Schlumberger, M.
Scott, G. H.
Smallwood, W.
Southwell, C. A. P.
Spielmann, P. E.
Stevens, L. C.
Strickland, A. F.
Taitt, G. S.
Tullett, G. V.
Tweed, R. R.
Underwood, A. J. V.
Walsh, D. M.
Walter, G.
Watling, R. A.
Westbury, J.
Wood, C. W.
Wood, N. E.
Young, J. H. M.
Oil Industries Club.
Shell Marketing Co., Central Laboratories.

The number of members (101) who supported the Fund during 1940 shows a very gratifying increase over previous years.

The Benevolent Fund Committee has been able to deal promptly with all cases requiring financial assistance which have arisen during the year. Important aid has been given to the widow and children of a former member of the Institute.

Finance.

The audited Revenue Account for the year and the Balance Sheet as at 31st December, 1940, are given below. The excess of income over expenditure for the year was £1370 14*s*. 4*d*. This surplus is ascribed to the enforced curtailment of meetings and other activities, a reduction in the *Journal*, and administration economies. It has been considered advisable to create a reserve for war contingencies. Accordingly the sum of £1250 has been transferred from the surplus to a War Contingencies Reserve, leaving a net surplus of £120 14*s*. 4*d*. to be transferred to the Balance Sheet. A donation of £105 has subsequently been made by the Council to the R.A.F. Benevolent Fund.

Compensation from H.M. Office of Works in respect of the requisitioned offices at the Adelphi has been received to the extent of £942 10*s*. This sum has been paid over to the owners of the Adelphi. In addition, a sum of £457 10*s*. has been received from H.M. Office of Works as compensation for requisitioned furniture. This is represented on the Balance Sheet by an investment of £500 in 3% Defence Bonds.

The Council expresses its thanks to the University of Birmingham and the Department of Oil Engineering and Refining for the continuance of office facilities at Birmingham. It is a very fortunate circumstance that close and continuous contact between the President and the executive staff should be possible at the present time.

The Council regrets to report that furniture from the Adelphi, which had been placed in store in London, was completely destroyed by fire in November, 1940, as the result of enemy action.

Meetings of the Institute.

Two Ordinary Meetings of the Institute and the Annual General Meeting were held in London during 1940. The Asphaltic Bitumen Group organized two meetings and the Lubrication Group one meeting. A notification of these Group meetings was given to all members in the London and Home Counties area. Particulars of the Papers read are given in the following Table :—

Date, 1940.	Subject.	Authors.
26th Jan.	Presidential Address: "The Development of Petroleum Refining."	A. W. Nash.
14th March.	"Viscosity and Constitution."	A. H. Nissan.
16th May.	Annual General Meeting: "Control of Oil Fires."	A. F. Dabell.
	Asphaltic Bitumen Group.	
16th Jan.	"Bitumen Emulsions in Soil Stabilization."	A. E. Lawrence.
	"Soil Mechanics in Foundation Engineering."	R. L. James.
16th April.	"Manufacture of Roofing Felts."	D. M. Wilson.
	Lubrication Group.	
22nd Feb.	"Testing of Greases."	M. W. Webber.

The programme of Papers arranged for the latter half of the year had to be cancelled owing to the inability of authors to devote the necessary time to the preparation of Papers, all of them being otherwise engaged on work of national importance.

Institute Luncheon.

By courtesy of the Council of the Royal Empire Society a Luncheon was held on 26th January, 1940, at the rooms of the Royal Empire Society. The Institute had the pleasure of welcoming the members of the Permanent Anglo-French Executive Committee for Oil.

The President presided over a gathering of about 180 members and guests. Among those present were the Rt. Hon. Lord Cadman, G.C.M.G., Col. L. Pineau, Sir Cecil Kisch, K.C.I.E., C.B., the Rt. Hon. Sir Ronald Graham, P.C., G.C.B., G.C.M.G., M. J. Filhol, and Sir Andrew Agnew, C.B.E.

Publications.

The Journal.

The monthly publication of Volume 26 of the *Journal* continued throughout 1940 in spite of some scarcity of Papers and the war-time rationing of paper supplies. A comparison with previous years is given in the following Table :—

	Journal of the Institute of Petroleum.		
	1938.	1939.	1940.
Papers published :—			
Read at Institute meetings in England .	8	35 *	2
Read at meetings of Branches or Groups .	3	5	10
Contributed Papers	33	20	21
	44	60	33
No. of Abstracts published	1469	1406	1621
No. of pages	1253	1304	1133

* Includes Papers of two special conferences.

The Table shows a gratifying increase in the number of Papers previously presented to one of the Branches or Groups of the Institute. In view of the difficulties of obtaining Papers from Great Britain, when so many members are engaged on work of urgent national importance, the Honorary Editor appealed to members in U.S.A., through Dr. G. Egloff, Chairman of the American members' Branch, to forward Papers for publication in the *Journal*. This appeal met with an immediate response, and several Papers have been promised from U.S.A. for publication during 1941.

The Council regards the *Journal* as of the greatest importance at the present time. It is the principal means available for carrying on the work of the Institute, and its publication will be maintained as long as possible.

All publications of the Institute are voluntarily submitted to and approved by the Ministry of Information, Trade and Technical Press Censorship Division, before they are issued. This arrangement has worked satisfactorily and expeditiously.

Despatch of the *Journal* to certain countries is made under the Defence

Regulations through the Postal Censorship. There are consequent delays in the receipt of the *Journal* by members abroad, but these are unavoidable. In cases where members' copies of the *Journal* have been lost in transmission by enemy action, the Institute will endeavour to replace these free of charge.

Petroleum Technology, Vol. V.

It was also possible to publish in September 1940 Volume V in the series of annual reviews of petroleum technology. This volume was as comprehensive as its predecessors. The Council records its appreciation of the collaboration of many scientists in the United States, without whose assistance such a complete survey of developments would not have been possible in present circumstances.

List of Members.

A re-issue of the List of Members (last published in 1936) was in preparation at the end of 1939, but has had to be postponed. Owing to frequent changes in address and the uncertainty of the whereabouts of many members, it is not considered advisable to re-issue the List of Members at present.

Chemical Standardization.

The following is a short account of the work of the Sub-Committees and Panels of the Chemical Standardization Committee which were active during 1940.

Kerosine. (Chairman: J. S. Jackson, Shell Marketing Co., Ltd.) A revised Burning Test for kerosine, K 35(T) 1940, was published in February 1940 (*J. Inst. Pet.*, **26**, 91–95). The revision extended the experimental details given in the Tentative Method of 1935 ("Standard Methods for Testing Petroleum," 3rd ed.), and included a closer specification for the wick, burner, and chimney.

Gum in Gasoline. (Chairman: W. H. Hoffert, National Benzole Co.) Investigations have been carried out by members of the panel with different bomb tests to determine the stability of gasoline. The object of these investigations is to make a recommendation as to the adoption or otherwise of the A.S.T.M. bomb test (D 525–40 T). This work is still in progress.

Knock-Rating of Aviation Fuels. (Chairman: W. L. Tweedie, Air Ministry.) Two meetings of the main committee and numerous meetings of its sub-committee were held during 1940. In April the Institute took over the correlation scheme for checking knock-ratings inaugurated by the Asiatic Petroleum Company. This scheme is now operated by the sub-committee.

Calibration curves for leaded secondary reference fuels C 12 and F 3 have been prepared. Calibration curves are also prepared for all new reference fuels as they become available in England, when such curves are not supplied from U.S.A. A tentative method for the knock-rating of experimental aviation fuels has been prepared and has also been published in the *Journal* (May 1941, **27**, 211, pp. 191–194).

There is a regular exchange of Minutes and Reports between this Committee and the C.F.R. Committee of America. Membership of the Institute's Knock-Rating of Aviation Fuels Committee includes representatives of the Air Ministry, the Ministry of Aircraft Production, aero-engine manufacturers, and the petroleum companies supplying aviation fuels.

Grease (Chairman: E. A. Evans, C. C. Wakefield & Co., Ltd.) The Grease panel has had before it the task of considering the whole question of the standardization of methods of testing greases. Members of the panel have carried out work on melting point tests, water estimation, and consistency. The panel hopes to be able to make some definite recommendations in the near future.

Measurement of Oil in Bulk. (Chairman: J. Kewley.) Work has been carried out on the preparation of tables of coefficients of expansion and gravity correction factors. In September 1939 this Committee was collaborating with the A.S.T.M. Committee on Sampling and Gauging, with the object of preparing a joint publication on the measurement of oil. This aspect of the Committee's work is temporarily suspended.

Asphaltic Bitumen and Cut-backs. (Chairman: P. E. Spielmann.) These two sub-committees have revised the I.P.T. Test C.B. 3 for the distillation of cut-back asphaltic bitumens. The revision is concerned with the procedure adopted at the termination of the distillation and during the pouring of the residue. The revised method is published in this *Journal* (pp. 226–229).

The secretarial work of all the above sub-committees has been ably carried out by Miss B. M. H. Tripp, and the Council records its appreciation of her valuable assistance.

Awards.

Two scholarships of £40 each, tenable by Students of the Institute at the Universities of London and Birmingham for the year 1940–41, were awarded to G. J. Clarke (Royal School of Mines) and A. H. Baldwin (Department of Oil Engineering and Refining, Birmingham University) respectively.

T. Y. Ju, Stud.Inst.Pet. (Birmingham University), was awarded the Students Medal and Prize for an essay on "The Behaviour of Fuels in C.I. Engines." A special prize was also awarded to D. G. Brunner, Stud.Inst.Pet. (Birmingham University), for an essay on "Mud Fluids for Drilling."

B. A. Murphy (Melbourne) and P. G. Owen (Birmingham) were highly commended for their essays.

No award of the Redwood Medal or the Burgess Prize was made in 1940.

Branches and Groups.

Stanlow Branch. A new Branch of the Institute was inaugurated on 13th March, 1940, at Stanlow, Cheshire. Mr. J. S. Parker was elected Chairman and Mr. J. C. Wood-Mallock Honorary Secretary. Addresses were given to the Branch by Dr. A. E. Dunstan (May 1940) and Prof.

A. W. Nash (January 1941). A regular monthly meeting has been held since October 1940.

Northern Branch. The ordinary meetings of the Northern Branch were suspended during 1940. A Luncheon Meeting was held in Manchester on 25th January, and was addressed by Prof. A. W. Nash on "Aviation Fuels and Lubricants." Mr. J. Cuthill has been elected Chairman of this Branch and Mr. E. J. Dunstan, Honorary Secretary.

U.S.A. Branch. The sixth annual meeting of members of the Institute in U.S.A. was held at the Stevens Hotel, Chicago, on 13th November, 1940. Addresses were given by Mr. T. A. Boyd and Dr. G. Egloff.

Scottish and S. Wales Branches. The meetings of the Scottish and S. Wales Branches were suspended during 1940.

Trinidad Branch. The annual report of the Trinidad Branch is printed on pp. 247.

Asphaltic Bitumen Group. Two meetings of the Asphaltic Bitumen Group were held in London during 1940. Particulars of the papers read are given above in the paragraph "Meetings of the Institute."

Research.

A grant of £15 was made to the British Electrical and Allied Industries Research Association in aid of investigations on the creep and corrosion of steels at high temperatures.

Council and Officers.

Professor A. W. Nash, M.Sc., M.I.Mech.E., was re-elected President of the Institute at the Annual General Meeting on 16th May, 1940. Professor Nash has also been nominated by the Council for a third term of office as President for the year 1941–42.

Mr. Ashley Carter, Mr. C. Dalley, Dr. F. H. Garner, Mr. J. McConnell Sanders, and Dr. F. B. Thole have been nominated Vice-Presidents for the year 1941–42.

The following were elected members of Council at the Annual General Meeting on 16th May, 1940: Mr. E. A. Evans, Mr. W. E. Gooday, Mr. J. A. Oriel, Mr. C. A. P. Southwell, Mr. A. Beeby Thompson, and Mr. C. W. Wood.

Five meetings of the Council and fifteen meetings of Committees of Council were held in London during 1940. At the May Council Meeting the number of committees of the Council was reduced to six, viz :—

Chemical Standardization .	Chairman :	Dr. F. H. Garner.
Election	,, :	Mr. J. McConnell Sanders.
Engineering Standardization .	,, :	Mr. A. C. Hartley.
Finance	,, :	Mr. C. Dalley.
Publication . . .	,, :	Dr. A. E. Dunstan.
Benevolent Fund . .	,, :	Dr. A. E. Dunstan.

Business previously dealt with by the Awards, Branch, House, Library, and Research Committees is now dealt with directly by the Council.

Acknowledgments.

The Council records its appreciation of the services to the Institute of the Rt. Hon. Lord Plender, G.B.E., Honorary Treasurer; Messrs. Price Waterhouse & Co., Auditors; Messrs. Ashurst, Morris, Crisp & Co., Solicitors; and the members of the Staff.

The Council also desires to thank the Council of the Institution of Chemical Engineers for permission to hold Council and Committee Meetings at 56 Victoria Street; the Councils of the Institution of Mechanical Engineers and the Royal Society of Arts for the use of their lecture halls; and the Midland Bank Ltd., Selly Oak, Birmingham, for banking facilities.

Approved for publication on behalf of the Council of the Institute.

Alfred W. Nash, President.
Arthur W. Eastlake, Honorary Secretary.
S. J. Astbury, Secretary.

21*st April*, 1941.

THE INSTITUTE OF PETROLEUM

BALANCE SHEET AND ACCOUNTS FOR THE YEAR ENDING 31st DECEMBER, 1940

THE INSTITUTE

REVENUE ACCOUNT FOR THE

	£ s. d.	£ s. d.	1939 £
To Administrative Expenses :—			
Staff Salaries	1514 17 5		1686
Printing and Stationery	182 6 2		294
General Postages	165 5 0		203
Telephone, Cables and Telegrams	6 0 0		20
		1868 8 7	
„ **Establishment Charges :—**			
Rent, Rates, etc.	530 5 11		809
Cleaning and Lighting	33 2 2		17
Repairs and Renewals	6 12 6		141
		570 0 7	
„ **Publications :—**			
Journal Expenses	1416 8 11		1635
Abstractors' Fees	246 1 7		221
Postage on Journals	189 17 8		217
Cost of other Publications	453 19 7		485
		2306 7 9	
„ **Meetings :—**			
Hire of Hall, Preprints, Reporting	118 19 4		283
Birmingham Meeting Expenses	—		125
		118 19 4	
„ **Professional Fees :—**			
Legal Expenses	50 0 0		37
Auditors' Fee	42 0 0		42
		92 0 0	
„ **Students' Scholarships and Prizes**		88 14 5	88
„ **Library Expenditure**		45 0 7	40
„ **Branches and Sections :—**			
Students' Section	10 0 0		18
Trinidad Branch	40 0 0		40
Northern Branch	5 0 0		35
Scottish Branch	—		5
South Wales Branch	—		10
Roumanian Branch	—		3
Branch Lectures	—		49
		55 0 0	
„ **Sundry Expenses**		149 10 7	184
„ **Depreciation of Office and Library Furniture**		149 0 0	50
„ **Removal and other Expenses re requisitioning of the Adelphi**		—	36
„ **Transfer to War Contingencies Reserve**		1250 0 0	—
„ **Balance, being Surplus for year, carried to Balance Sheet**		120 14 4	155
		£6813 16 2	£7123

RESEARCH FUND INCOME AND EXPENDITURE

	£ s. d.
To Grant Made During Year :—	
British Electrical and Allied Industries Research Association	15 0 0
„ **Balance as at 31st December, 1940**	142 16 1
	£157 16 1

OF PETROLEUM

YEAR ENDED 31 DECEMBER, 1940

	£	s.	d.	1939 £
By Subscriptions for 1940 received	3583	9	1	3894
„ Special Subscription	20	0	0	20
„ Subscriptions in Arrear received during Year	72	8	6	94
„ Publications	2400	3	2	2891
„ Interest and Dividends (Gross)	237	15	5	224
„ Grant in aid of Rent	500	0	0	—
„ Compensation Received from H.M. Office of Works. £ 942 10 0				
Less Paid to the Adelphi 942 10 0	—			—
	£6813	16	2	£7123

ACCOUNT FOR THE YEAR ENDED 31ST DECEMBER, 1940.

	£	s.	d.
By Balance as at 31st December, 1939	147	14	4
„ Interest Received During Year	10	1	9
	£157	16	1

THE INSTITUTE

(A Company limited by Guarantee

BALANCE SHEET AS

	£	s.	d.	£	s.	d.
Capital of the Institute under Bye-Law, Section 6, Paragraphs 14 and 15 :—						
Life Membership Fund,	£	s.	d.			
As at 31st December, 1939	811	7	0			
Additions during year	6	7	0			
				817	14	0
Entrance and Transfer Fees—						
As at 31st December, 1939	3538	2	9			
Additions during year—						
Entrance fees	97	3	0			
Transfer fees	7	7	0			
				3642	12	9
Profit on Sale of Investments—						
As at 31st December, 1939				351	10	11
Donations—						
As at 31st December, 1939				326	5	0
						5138 2 8
Research Fund						142 16 1
T. C. G. Burgess Prize Fund						10 0 0
War Contingencies Reserve						1250 0 0
Members' Subscriptions received in advance						78 19 0
Journal Subscriptions received in advance						148 13 3
Sundry Creditors—General Account						436 18 1
World Petroleum Congress						212 15 3
Revenue Account :—						
Balance as at 31st December, 1939				1946	4	9
Add Surplus for year as per separate statement				120	14	4
Add Compensation received from H.M. Office of Works for Furniture Requisitioned				457	10	0
						2524 9 1

ALFRED W. NASH, President.
C. DALLEY, Chairman, Finance Committee.

£9942 13 5

AUDITORS'

We report to the Members of THE INSTITUTE OF PETROLEUM that we have obtained all the information and explanations we have required. We are of the correct view of the state of the Institute's affairs as at 31st December, 1940, according the books of the Institute.

3, FREDERICK'S PLACE,
OLD JEWRY, LONDON, E.C.2.
7th April, 1941.

OF PETROLEUM.

and not having a Share Capital.)

AT 31ST DECEMBER, 1940.

	£ s. d.	£ s. d.
Investments :—		
On Account of Capital, at cost—		
£461 12 0 3% Conversion Stock (1948/53)	491 12 6	
664 6 6 3% London County Consolidated Stock, 1920	481 10 6	
806 8 3 3% Manchester Corporation Redeemable Consolidated Stock, 1958	845 17 7	
867 8 6 2½% Bristol Corporation Redeemable Stock, 1955/65	845 17 7	
150 0 0 5% Wandsworth and District Gas Co. Debenture Stock	154 8 6	
400 0 0 3% Metropolitan Water Board "A" Stock, 1963	346 10 7	
125 0 0 5% Great Western Railway Co. Consolidated Preference Stock	105 4 9	
150 0 0 3% Luton Corporation Redeemable Stock, 1958	151 6 7	
150 0 0 3% Smethwick Corporation Redeemable Stock, 1956/58	151 4 9	
600 0 0 3% Bristol Corporation Redeemable Stock, 1958/63	597 7 3	
	4171 0 7	
(Market Value at 31st December, 1940, £4,047 16*s.* 4*d.*)		
Cash awaiting Investment on Deposit with Post Office Savings Bank	967 2 1	5138 2 8
On Account of Revenue, at cost—		
£790 8 3 3% Conversion Stock	842 8 0	
£500 0 0 3% Defence Bonds.	500 0 0	
	1342 8 0	
On Account of Research Fund, at cost—		
£336 5 10 3% Conversion Stock	357 14 8	1700 2 8
(Market Value at 31st December, 1940, £1660 9*s.* 6*d.*)		
Office and Library Furniture (excluding Presentations) :—		
As at 31st December, 1939	150 0 0	
Less Depreciation	149 0 0	1 0 0
Library Books (excluding Presentations) :—		
As at 31st December, 1939.		—
Subscriptions in Arrear :—		
Not valued.		—
Sundry Debtors, less Reserve for Doubtful Debts		355 0 3
Cash at Bank on Current Account		868 1 7
Cash on Deposit :—		
Post Office Savings Bank	1667 11 0	
World Petroleum Congress Account	212 15 3	1880 6 3
		£9942 13 5

REPORT.

examined the above Balance Sheet with the books of the Institute and have opinion that such Balance Sheet is properly drawn up so as to exhibit a true and to the best of our information and the explanations given to us, and as shown by

PRICE, WATERHOUSE & Co.

T

BENEVOLENT FUND.

RECEIPTS AND PAYMENTS ACCOUNT FOR YEAR ENDED 31ST DECEMBER, 1940.

RECEIPTS.	£ s. d.	£ s. d.	PAYMENTS.	£ s. d.
Balance on Current and Deposit Accounts on 1st January, 1940 :—			**Benevolent Fund :—**	
Benevolent Fund Account		763 2 0	Grants in aid	68 18 6
Receipts during 1940 :—			**Balance on 31st December, 1940 :—**	
Subscriptions	45 19 6		Benevolent Fund	815 5 2*
Donations	55 6 6			
Interest	12 8 8			
Income Tax recovered	7 7 0			
		121 1 8		
		£884 3 8		£884 3 8

* The Balance on Current Account and invested on 31st December, 1940, was made up as follows :—

	£ s. d.
Cash on Current Account	86 8 2
3% Local Loans at cost	528 17 0
3% Defence Bonds	200 0 0
	£815 5 2

A. E. DUNSTAN, Chairman, Benevolent Fund Committee.
ALFRED W. NASH, President.

We have examined the above Receipts and Payments Account with the books and vouchers of the Fund and find it to be in accordance therewith. We have verified the Investments and Balances with Bankers comprising the Balance on 31st December, 1940: £815 5 2.

3, FREDERICK'S PLACE,
OLD JEWRY, LONDON, E.C.2.
7th April, 1941.

PRICE, WATERHOUSE & Co.

TRINIDAD BRANCH.

REPORT OF THE COMMITTEE ON THE WORKING OF THE BRANCH DURING THE SESSION 1939–1940.

FOUR meetings were held during the session, at which the following papers were read :—

January 10th, 1940.	12th Annual General Meeting: "Some Aspects of Industrial Relations," by R. Gavin.
February 28th, 1940.	61st General Meeting: "Errors in Acid Bottle Readings," by G. H. Scott. "Evaluation of Rotary Drilling Lines," by H. C. H. Darley.
May 1st, 1940.	62nd General Meeting: "Control of Drilling Mud in the Field," by H. C. H. Darley.
June 26th, 1940.	63rd General Meeting: "The Effects of Crooked Hole on Exploitation," by H. C. H. Thomas.

The average attendance of members and guests at meetings was 25.

There were 73 members on the roll at the end of the year.

Mr. L. A. Bushe was elected Chairman.

Mr. A. F. Castle was deputed to act for Mr. C. C. Wilson, who had been elected Hon. Secretary and Treasurer, and who was incapacitated by illness.

The Annual Dinner was not held on account of the war.

The Accounts for the year ended 31st October, 1940, are printed on the following page.

Signed A. F. CASTLE, *Hon. Secretary.*
„ L. A. BUSHE, *Chairman.*

20th January, 1941.

THIRTEENTH ANNUAL GENERAL MEETING OF TRINIDAD BRANCH.

29TH JANUARY, 1941.

THE thirteenth Annual General Meeting of the Trinidad Branch was held at the Apex Clubhouse on 29th January, 1941. Mr. L. A. Bushe occupied the Chair.

On the proposition of Mr. A. H. Richard, seconded by Mr. J. D. Fullerton, the Committee's Report on the year's working of the Branch, together with the Accounts for the Session ended 31st October, 1940, were unanimously adopted.

The Chairman observed that contributions from the Trinidad Branch to the Benevolent Fund of the Institute totalled $140.80 in two years 1939 and 1940. This was the equivalent of $1.00 per head of the members in Trinidad, as compared with 8*d.* per head over the whole membership of the Institute. It seemed likely that the Branch would be sending $70 to $80 per annum.

The accounts were very satisfactory, although the surplus was partly due to the fact that the usual Annual Dinner had not been held.

As a result of a ballot, the following were elected officers and members of Committee for the ensuing Session: Messrs. L. A. Bushe (Chairman),

A. F. Castle (Hon. Secretary), H. W. Reid, G. S. Taitt, H. C. H. Thomas, F. H. L. Tindall and C. Wilson.

A vote of thanks was unanimously accorded to the auditors, Messrs. H. A. Harris and F. E. Hunter.

At the conclusion of the Annual General Meeting Mr. G. Stewart Taitt read a Paper on "A Note on the Sealing Effect of Fault Surfaces."

TRINIDAD BRANCH.

Balance Sheet as at 31st October, 1940.

Liabilities.			Assets.		
Subscriptions to Benevolent Fund to be remitted to London			Cash at Bank		$577.67
Income and Expenditure Account:			Cash in Hand		3.05
As at 31st October, 1939		$295.61			
Excess Income over Expenditure for year ended 31st October, 1940		144.31			
As at 31st October, 1940		439.92			
		$580.72			$580.72

Income and Expenditure for Year Ended 31st October, 1940.

Expenditure.		Income.	
Stationery, Printing and Postage	$28.62	Grants from Institute of Petroleum, London	$192.00
Clerical Assistance	18.08		
Telephone	.99		
	$47.69		
Excess Income over Expenditure	144.31		
	$192.00		$192.00

(*Signed*) L. A. Bushe, *Chairman.*
A. F. Castle, *Hon. Secretary and Treasurer.*

F. E. Hunter } *Auditors.*
H. A. Harris }

ANNUAL GENERAL MEETING.

1st May, 1941.

The Twenty-Eighth Annual General Meeting of the Institute was held at the Connaught Rooms, London, W.C. 2, on Thursday, 1st May, 1941, at 3.30 p.m. The Chair was taken by the President, Professor A. W. Nash.

The Secretary (Mr. S. J. Astbury) read the Reports of the Auditors.

The Minutes of the Twenty-Seventh Annual General Meeting were read, confirmed and signed.

NEW MEMBERS.

It was agreed that the list of Fellows, Members, Associate Members, and Students elected and transferred during 1940 should be laid on the table.

ELECTION OF MEMBERS OF COUNCIL.

The Secretary announced that, in accordance with the Articles of the Institute, the following members of Council retired at the Annual General Meeting but offered themselves for re-election: Messrs. A. F. Dabell, V. C. Illing, E. R. Redgrove, and W. J. Wilson. One new nomination had been received, on behalf of Mr. Robert Crichton, J.P., General Manager, Scottish Oils, Ltd. The Council decided that, in view of the present circumstances, a postal ballot should not be held, and the names of the above five candidates were therefore submitted to the Meeting to fill five vacancies on the Council.

On the motion of the President, the names of these five candidates were put to the Meeting and unanimously elected Members of Council.

The President then moved :—

> "That the Annual Report of the Council for the year 1940, together with the Accounts and Balance Sheet as at 31st December, 1940, be and are hereby adopted."

In doing so, he said that the Report had been circulated to all the members, and he would therefore be glad if, for the purpose of the meeting, it might be taken as read. (*Agreed.*)

The work of the Institute had naturally been considerably handicapped during the past year. They had not been able to enjoy their usual programme of meetings for several reasons—shortage of papers, difficulties of travelling, the black-out, and air raids. The work of the technical committees dealing with the standardization of methods of test had also been slowed down. Some of the members of these committees had had to transfer their attention to work of more immediate national importance.

The *Journal* had continued throughout the year, although its pages were somewhat fewer than usual. This was due to a shortage of papers. The Honorary Editor, Dr. Dunstan, had appealed to their American colleagues for support, and Dr. Egloff and others had immediately responded with offers of papers, one of which was presented to a meeting of the Institute in March. There were signs, however, that this source of contribution would soon become dried up. The Americans, like ourselves, were becoming more and more engrossed in the tasks of national defence. Only the other day a cable was received from Dr. Mackenzie regretting his inability and that of his colleagues in the Texas Company to write their usual article for the Annual Reviews.

The Council had decided, however, to turn the normal winter session into a summer session as far as circumstances and papers would permit, and monthly meetings would be held in London up to September. They would be sorry to hear that the Royal Society of Arts, where these meetings would have been held, had suffered badly in a recent raid. Their sympathies would go out to that old-established Society, which had been a good host to the Institute on so many occasions. It was second only to the Royal Society in date of foundation. The glass in some of the windows of the building in John Adam Street, recently devastated by German bombs, had been in position since 1780. The same raid caused some damage to the Institute's old offices at the Adelphi, but he was pleased to say that the library had so far escaped intact.

Members would welcome the formation during 1940 of a new branch of the Institute at Stanlow. This Branch was in a very flourishing condition under the chairmanship of Mr. J. S. Parker, and with the collaboration of Mr. Oriel, a member of Council, had had an active session.

In conclusion he wished to thank his colleagues on the Council for their whole-hearted support during his second year of office as President. They had honoured him by asking him to take office for a third year, and he had accepted the invitation, although the Bye-laws and normal practice required him to relinquish his office at the end of the second. But he would be very glad to do what he could for the members and the Institute for a further term. The war period was inevitably a period of marking time. They had to defer their schemes for the development of the Institute and to maintain as good a service as possible for their members through the *Journal* and such meetings as they could arrange. (*Applause.*)

Mr. ASHLEY CARTER (Deputy-Chairman, Finance Committee) seconded the adoption of the Annual Report and Accounts. Mr. Carter regretted the unavoidable absence of Mr. Christopher Dalley, Chairman of the Finance Committee, and referred to the remarks which Mr. Dalley would have made if he had been able to be present. Mr. Dalley's observations on the Annual Accounts are given below :—

"Members would see from the printed statements of accounts that there was a surplus of income over expenditure in 1940 of £1370. To a great extent economies had been forced upon them, by a reduction in the number of meetings, in the size of the *Journal* and the numbers printed month by month. The Finance Committee and Council had thought it prudent to transfer £1250 of this surplus to a War Contingencies Reserve, and he was sure every member would agree that this was a wise precaution at the present time. They could not foresee what reduction in income would take place in the next few years. The Council had decided to adopt a policy of conserving the resources of the Institute, so that they could maintain the *Journal* and essential activities as long as possible.

"The *Journal* was bringing in to the country a small but appreciable amount of dollar exchange. It was estimated that £2500 of the total income during 1940 was remitted from dollar countries. Such remittances would ultimately find their way back to the United States, via the Treasury, to be spent on essential armaments.

"Members would note from the Balance Sheet that all their assets were in a liquid form, either existing as investments, as cash in the Post Office Savings Bank or as cash on current account. During the year £500 had been invested in 3 per cent. Defence Bonds. A further £500 had been invested in the previous week. Members could rest assured that cash surplus to immediate requirements would be lent to H.M. Government as early as it became available.

"On the question of the Adelphi, the position was fully explained by the entries on the Revenue Account. Whatever compensation they had received from H.M. Office of Works had been immediately paid over to the owners of the Adelphi building. The Council had repeatedly affirmed that it had no desire to make any profit out of compensation received for the requisitioning of its offices. With the full approval of the Institute's solicitors it had agreed to pass over whatever monies it received by way of compensation."

The motion to adopt the Annual Report and Accounts was carried unanimously.

In reply to a question by a member, the Secretary stated that periodicals formerly received at the Adelphi, except those from European countries, were still being received and bound. The bound volumes for 1939 and 1940 were at Birmingham, and available on loan to members. As regards new books, there were not so many published nowadays. Such new books as related to petroleum and allied subjects were either received for review or obtained by purchase and added to the library. They were noted in the *Journal* either as a "Book Review" or "Book Received," and any book referred to therein could be borrowed through the post by members. Last year about twenty-five or thirty new books (as distinct from pamphlets and periodicals) had been added to the library.

ELECTION OF AUDITORS.

On the proposition of Capt. W. H. CADMAN, seconded by Mr. J. T. WARD, Messrs. Price Waterhouse & Co. were re-elected auditors for the ensuing year.

The proceedings of the Annual General Meeting then terminated, and the President declared the meeting closed.

PRESIDENTIAL ADDRESS.

Following the Annual General Meeting, the President delivered an Address on "Petroleum as a Raw Material" printed on pages 195 to 213 of this issue of the *Journal*.

VOTE OF THANKS TO THE PRESIDENT.

Mr. J. KEWLEY proposed a hearty vote of thanks to Professor Nash. He said that it was typical of Professor Nash that he had chosen to deal with the most modern developments in the petroleum industry. The members present had had two good meals that afternoon—one physical and the other intellectual. This second one, in the shape of the Address, was perhaps somewhat difficult of digestion. But the President had only given them a *résumé* of his Address, and had left them to complete the digestive process at their leisure.

During past years, at the University of Birmingham, Professor Nash had carried out some pioneering work, and his Address itself was significant as a spear-point of petroleum development. The proposer's function was simply to say grace after this intellectual meal, and to ask the members to thank Professor Nash for his excellent Address.

Mr. T. DEWHURST seconded the vote of thanks, and said that, apart from the Address, which had a special value, they were deeply indebted to the President for his control of the interests of the Institute in these very troublous times, and for presiding for an exceptionally long and difficult period. Those who were on the Council had special opportunities of appreciating the application and wisdom which he devoted to the affairs of the Institute.

The vote of thanks was put to the meeting by the Seconder and carried with applause, and the President briefly acknowledged the compliment.

The meeting then terminated.

OBITUARY.

WILLIAM HENRY HOWE.

By the death of William Henry Howe, the lubricating oil trade in general and the smaller distributors in particular have lost a very good friend—a friend who during the past twenty years devoted a great deal of time and energy to a determined effort to bring about a spirit of trust and understanding between all firms engaged in the lubricating-oil trade.

Mr. Howe was a happy combination of commercial and technical ability, and realized that the user of lubricants is entitled to expect advice on the selection and application of the product on which depends the efficiency of his machinery. Feeling that he himself could not know too much about his subject, Mr. Howe joined the Institute as an Associate Member in 1928, and was elected a Fellow under the revised constitution in 1939. He regularly attended the Institute meetings and kept in close touch with American progress. The National Lubricating Oil & Grease Federation owe a great deal to his staunch support, and he twice filled the office of President (1928–9 and 1931–2)

All those who had the privilege of knowing him will greatly miss his cheerful personality and will deeply regret his passing.

E. R. REDGROVE.